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Regional Distribution of Green Growth Patents in four Nordic Countries: Denmark, Finland, Norway and Sweden

Report

2019

By

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Preface

This report is part of the project on The Geography Of Nordic Sustainability Transitions (GONST). In the project researchers from Lund University, Aalborg University, University of Tampere, NIFU, SINTEF, and the Technical University of Denmark ask the question "Where does the green economy grow?" The project is generously funded by the Nordic Green Growth Research and Innovation Programme in cooperation with NordForsk, Nordic Innovation and Nordic Energy Research [Grant no. 83130].

The starting point for the project is the idea that there is no one-size-fits-all approach to greening the growth path of an economy as this depends on place-based policy and institutional settings, level of development, resource endowments and particular environmental pressure points. The GONST project addresses the place-based, context-dependent nature of the shift to green growth in the Nordic countries by asking the question: where does the green economy grow? In addressing this question, we foreground the importance of innovation, new industry formation, and radical industry transformation.

The GONST project is based on a mixed methods approach building on qualitative and quantitative techniques. Quantitative techniques will be applied to analyse the importance of human capital and technological specialisation for the greening of the economy. Qualitative case studies of Nordic regions will focus on the role of institutions and account for the diversity in Nordic regional green pathways.

This report fulfils the first delivery of work package three (WP3) on mapping the technological specialisations of regions across the four Nordic countries: Denmark, Finland, Norway and Sweden. The mapping in this report will be followed up by more analytical tasks in order to understand the patterns of green patenting activity across Nordic regions.

This report draws on the contributions of the WP3 researchers who have discussed the design and challenges of mapping green patent activity in the Nordic countries as well as carried out the mapping: Eric Iversen (NIFU), Christian Østergaard and Eun Kyung Park

(Aalborg University), Markus Grillitsch (Lund University) and Lourenco Faria, Mariú Abritta Moro and Anne Nygaard Tanner (Technical University of Denmark (DTU)). The report has also benefited from discussions with the rest of the GONST research team at the GONST Annual Meeting, held at DTU in March 2018.

Content

List of Tables

Tables in Appendix C:

List of Figures

Summary

This report is part of the project: “Where does the green economy grow? The Geography Of Nordic Sustainability Transitions (GONST)“. The project is funded by the Nordic Green Growth Research and Innovation Programme in cooperation with NordForsk, Nordic Innovation and Nordic Energy Research [Grant no. 83130].

The aim of this report is to map green patenting activity across regions in the Nordic countries: Denmark, Finland, Norway and Sweden. It is a descriptive exercise with the objective to provide a baseline overview of the regional patterns of green technological specialization in the Nordic countries. We have used the EPO (European Patent Office) Register accessed through the PATSTAT offline database (version October 2017) for most of the analysis. For comparison, a subsequent version of the database (PATSTAT 2018b) is used to illustrate differences between different categorization schemes. However, for purposes of illustration, this report defines Green Growth Technologies according to the CPC Y02-tags schema. The focus is solely on patent applications filed with the EPO since 2000. The descriptive analysis is based on different measures such as patent counts, shares, Revealed Technological Advantages [RTA] and Herfindahl index.

The introduction contains a discussion of how to define green technologies and issues related to this task. Also, we discuss and assess different means (i.e., patent classification systems) to identify patents that correspond to green technological development. The EPO Y02-tags system is nominated here as the best first approach as it tends to reduce the risk of Type I error (inclusion of patents that are not green technologies even though they belong to categories defined as green in these classifications) as well as that of Type II error (the possibility of not including important green patents that do not contain any of the IPC codes listed in the classification).

In Chapter 2 of this report we map the green patenting activity at both the country- and regional level based on the Y-tag scheme. First, we highlight that green patenting activity is strongly linked to the propensity to patent in general (i.e. also non-green technologies) and differs a lot across the Nordic countries. In total we identified 8,300 European green patents stemming from the Nordic countries in the period 2000-2014. The lens used in this report confirms a strong upward-sloping trend in Nordic green patenting in Europe. It also illustrates that the different

Nordic countries contribute differently to green patenting in Europe: Denmark (37%) and Sweden (35%) account for the largest shares of patents applied for at the European level followed by Finland (20%) and Norway (9%).

The country sections (Section 2.1 to 2.4) describe the mapping of Climate Change Mitigation (CCM) technologies for NUTS2 regions for each of the countries using this lens. The sections show:

- **Denmark's** green patenting activity is specialised within CCM technologies related to Energy (83% of 3,100 patent families). Within Energy related technologies most patents are on renewable energy generation (79%). The regions that dominate green patenting activity are Midtjylland (Central Denmark region), Syddanmark (Southern Denmark region) and Hovedstaden (Capital region).
- **Finland** are more diverse with 75 % of their 1,700 green patents distributed evenly across three CCM technologies, namely Production or processing of goods, Energy, and Buildings. However, in Finland the patent activity is more geographically concentrated, showing that Helsinki-Uusimaa and Länsi-Suomi, contribute to about 74% of all CCM technology patent families.
- **Norway** filed the smallest number of green patents at the EPO (less than 800) according to this definition. The mapping demonstrates a very even geographical distribution of green patents (with the exception of Hedmark and Oppland, and North-Norway, which have very few patents). Norway specialise in CCM technologies related to Energy (42 %) and Production or processing of goods (23 %).
- **Sweden's** leading regions in CCM technology are Stockholm, Västsverige and Östra Mellansverige. Sweden's stronghold in the automotive industry is reflected in the strong position on CCM technologies related to Transport with more than 900 patent families followed by technologies related to Energy (740), Buildings (660) and Production and Processing of goods (430).

1. Introduction

This report takes stock of how different regions in the Nordic countries contribute to 'green patenting'. The idea is that if ‘green patents’ can reliably be defined, it is possible to use them to trace important points of origin for novel technologies that are designed to address environmental challenges. The intuition, shared by a growing body of mainly policy-oriented research, is that patenting provides a useful – but imperfect— indicator to trace where the growth of new ideas is happening in the 'green economy'. Patents provide a lens on this phenomenon. The features of the patent lens, however, may magnify or minimize, may bring into relief or overlook, different aspects of the phenomenon that we are studying: it important to appreciate these features. The report reviews recent literature to better understand how green patenting can be used to understand 'where green technologies grow' at the regional level in the Nordic countries. The state-of-the art[1] emphasizes the point that using patents as a lens is not black-and-white, especially not in the realm of the green economy. It is therefore of key importance to begin with some fundamental definitions.

1.1 How to define green technologies?

Despite being largely used by specialized reports, newspapers, academic papers, blogs and patent offices, there is no formal, clear and widely accepted definition of green technologies and consequently of “green patents”. The common denominator among academics and policymakers is that green technologies have a lower environmental impact than their immediate alternatives whether for purposes of electricity generation, passenger or cargo transport, manufacturing processes, etc. (OECD, 2011).

The precise definition of the group of technologies that can be considered green is challenging due to several issues, such as 1) the systemic nature of technologies; 2) the level of technological

[1] For a useful discussion of the patents as a measure to aid energy and climate policy, see e.g. OECD (2012), Energy and Climate Policy: Bending the Technological Trajectory, OECD Studies on Environmental Innovation, OECD Publishing.

maturity; 3) changing perceptions of sustainability; and 4) intended or unintended environmental benefits.

1.1.1 The systemic nature of technologies

Many technologies are systemic by nature and depend on other related innovations and technologies to be considered green *de facto* (Andersen, 2004; Nill & Kemp, 2009; Oltra & Saint Jean, 2009). To evaluate the overall greenness of an electric vehicle, for instance, one should include the impact of its production processes, battery deployment regulations and energy production structure. That is because the environmental impact of electric cars depend on the impact of the electricity source (e.g. coal, nuclear, renewable), but also on how the batteries are made and disposed, since the components that are used to make such batteries are hard to extract and process and might cause great environmental harm to the soil and water systems if not correctly handled when disposed.

While the production process and battery disposal can be somehow tracked by the manufacturer, the electricity source relies on country- or region-specific institutions and infrastructures. Thus adopting a strict environmental impact rule, the same electric vehicle could be considered a green technology or not depending on the characteristics of the market where it is sold. Additionally, many components aiming at improving systemic green technologies' attributes (for example performance, safety, comfort, noise level, durability, compatibility with other technologies etc.) might not present any effective environmental gain, although they might be crucial to the diffusion of the technology by improving its features. An example of that might be a general hardware component that improves electric cars' performance or handling but does not offer any direct environmental benefit.

1.1.2 The level of technological maturity

Technologies usually need some time to improve its characteristics before it reach an acceptable performance degree, and that includes their environmental impacts. Some technologies can display potential environmental gains, but they may require a certain period of experimentation to reach this point, with the risk that they never reach such gains due to technological or economic barriers. Moreover, there are many different methods for evaluating the environmental impact of a new technology, from life-cycle assessment (LCA) tools to rules of thumb and checklists. The most accurate methods (streamlined and full LCA) are time- and resource-consuming, especially for complex technologies and value chains. Different methods may also generate different, often contrasting results. It remains almost impossible to assess the overall environmental impacts of some potentially green technologies and to compare these with existing technologies (Bocken et al., 2012), especially when considering rebound effects and other issues that may not be predicted before the mass-market diffusion of a technology (Jänicke, 2012).

1.1.3 Changing perceptions of sustainability

The idea of what is considered green is also constantly changing and is dependent on consensus among stakeholders. The concept of green is dynamic and dependent on the challenges and achievements already made towards the green economy. Technologies today considered green might not be regarded as such in the future once they become the dominant designs (Allenby, 2000). Technologies related with the bioeconomy, for example, are considered today as green technologies by many (although there is no consensus about that), while they were not considered green in the past. When first disseminated, internal combustion engine cars were seen as a clean alternative since they solved a major problem in big cities such as London and Paris, namely the huge amount of horse manure in the streets (Geels, 2005). Not so long ago, Diesel cars were also praised as clean, especially by European governments, as they claimed these vehicles would emit less pollutants, which has been contested recently[2].

1.1.4 Intended or unintended environmental benefits

The level of greenness of a technology can include both *intentionally and unintentionally* efforts from the actors (i.e. Klemmer *et al.*, 1999*;* Rennings, 2000; OECD, 2009; Beise & Rennings,

[2] See for instance: https://www.nytimes.com/2016/01/03/opinion/sunday/the-dirty-truth-about-clean-diesel.html

2005; Carrillo-Hermosilla *et al.*, 2010). Intentionality here is understood as the explicit intention (or lack of) of an inventor/innovator to produce a product or process which has a reduced environmental impact. Sometimes, environmental benefits may arise from the use of a technology that was not designed to be sustainable. The diffusion of computers and especially ICTs, for instance, had a positive impact on the consumption of paper since people started using emails and reading on screens instead of reading and writing on paper, even though these technologies were never designed with the environmental benefits in mind. From the environmental impact point of view, new technologies with *unintended* environmental gains are as important as the ones with intended gains. However, unintended environmental gains are the *random side of the greening process* and are *exogenous*, thus difficult to predict, manage and influence by policy mechanisms usually described in the traditional innovation literature (Lundvall & Borrás, 2005). Entities (firms, organizations, regions, countries) producing technologies that have widely known *intended* environmental gains, on the other hand, are likely demonstrating real commitment with the greening of the economy.

Therefore, given these limitations, the group of technologies that are considered to be green is usually defined based on a consensus among several actors such as policymakers, relevant organizations, academics and business entities. The most important examples of this is classification schemes, such as "Climate Change Mitigation Technologies" (CCMT) and "Environmentally Sound Technologies" (EST), both of which were disseminated by the United Nations Framework Convention on Climate Change (UNFCCC)[3] and used as base concept by

[3] "The United Nations Framework Convention on Climate Change (UNFCCC or FCCC) is an international environmental treaty negotiated at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. It entered into force on 21 March 1994 and today it has near-universal membership. The 195 countries that have ratified the Convention are called Parties to the Convention. The UNFCCC's main aim is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interferences with the climate system." Source: http://unfccc.int

several organizations (e.g. OECD, EPO), academics and policymakers. These definitions are frequently used as synonyms, although there are important conceptual differences among them. For instance, the CCMTs are defined as those "which can be related to a human intervention directed to reduce the sources or enhance the sinks of greenhouse gases" (Veefkind *et al.*, 2012, p. 106), while ESTs are broader, encompassing other environmental issues such as soil and water pollution.

The formal definition of EST according to the United Nations (UN)[4] is: "Environmentally sound technologies are techniques and technologies capable of reducing environmental damage through processes and materials that generate fewer potentially damaging substances, recover such substances from emissions prior to discharge, or utilize and recycle production residues." To meet this definition, technology fields are chosen in an objective way by identifying technical features that lead to reduced environmental impact. Examples of such technology fields are water and waste management, renewable energy production and distribution, zero emission transportation etc.

Although there is no perfect way to overcome the challenges listed above and to define green technologies it is important to work towards an objective classification system to generate a practical and workable definition that can be used for policymaking, firm strategy, as well as for research purposes.

1.2 Green patent coverage

Green patents are usually defined for two purposes: 1) for administrative reasons such as implementation of fast-track programs in patent offices, and 2) for research and analysis of

[4] Source: UN (1997). Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997.

patenting trends and individual documents. In the former case, patent offices define patents as green using both objective and subjective elements, since it is usually a process of examination case by case that defines if a patent can be considered green and, for example, is eligible for a fast-track program[5]. A fast-track program allows patent applications to be examined as a matter of priority by intellectual property offices in order to reduce the waiting time for applications (Dechezleprêtre, 2013). While some patent offices follow objective, technical definitions chosen by their own experts or following other established definition, e.g. USPTO, KIPO (South Korea), INPI (Brazil) and SIPO (China), other patent offices prefer subjective definitions such as green patents as all technologies that have some positive effect on environment, independently of their technological field e.g. UKIPO (United Kingdom), JPO (Japan), Israel Patent Office, and CIPO (Canada). In these cases, the applicant has to demonstrate some environmental gain arising from the invention that is then evaluated by the examiner.

For the purpose of research and analysis of patenting trends, subjective descriptions of green patents are of little use, since the process often involves searching specific patent information from databases that contain thousands or millions of documents. The practical alternative is the adoption of an ad hoc *patent filter* (D'Amato et al., 2015).

Examples of widely used patent filters are 1) sets of keywords or 2) sets of IPC/CPC codes[6] that select technologies considered as green based on their technological area. Each of them has advantages and drawbacks. Veefkind et al. (2012) characterize the main issues related with choosing a filter-approach by two errors: Type I and Type II. The Type I error relates to the inclusion of patent documents that are not green technologies even though they belong to

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[5] Fast track programs allow patent applicants to start licensing their technologies sooner, thereby reducing the time to reach the market. Green patent fast-track schemes have been expected to accelerate the diffusion and encourage inventive activity of clean technologies, albeit they vary widely in their requirements for eligibility and participation. The first IP office to implement this scheme was the United Kingdom IP office in 2009, followed by several

[6] The International Patent Classification (IPC) provides for a hierarchical system of codes for the classification of patents according to the different areas of technology to which they pertain, commonly referred as IPC codes.

categories defined as green in these classifications. The Type II error, on the other hand, refers to the possibility of not including important green patents that do not contain any of the IPC codes listed in the classification. Using keywords might increase the probability of incurring in the type II error simply because many green patents may not contain the chosen keywords in their abstracts or title even though they represent green technologies. Since patenting systems are not perfect and firms want to disclosure few information as possible to their competitors, some inventors might choose to avoid using specific words in the patent documents. IPC/CPC codes overcome these issues since it is attributed by the examiners as well. However, green technologies often do not belong to specific IPC groups but are scattered throughout many distinct technological fields. Therefore, classifications based on specific technology areas tend to generate more "noise" (patents with no green content) while also not including green patents that are not covered by the classifications. As we will see, however, there are ways to overcome this issue.

1.2.1 Green Patent Classification systems

The WIPO's Green Inventory, the OECDs ENV-TECH, the EPO's Y-tags, as well as reports such as the Fraunhofer ISI's list of IPC classes for Societal Grand Challenges which adapts and extends different schema to create a crosswalk between IPC/CPC codes and technological fields that may be associated with 'societal grand challenges' , including as climate change and other 'green' areas. In the following subsections, we will present these classifications in more detail.

WIPO's Green Inventory

The WIPO's Green Inventory was launched on September 16, 2010 as a reference page in the WIPO's website[7]. It adopts the set of green technologies (CCMT) identified by the Secretariat

[7] http://www.wipo.int/classifications/ipc/en/green_inventory/

of the United Nations Framework Convention on Climate Change (UNFCCC) and contains around 200 topics organized in seven major technological areas connected to IPC codes chosen by experts from all WIPO Member States: Alternative Energy Production, Transportation, Energy conservation, Waste management, Agriculture/Forestry, Administrative, Regulatory or Design Aspects[8], and Nuclear Power Generation.

According to Veefkind et al. (2012), the main disadvantage of this classification is that it tries to associate directly IPC codes to categories of environmentally sound technologies, thus often the technological areas indicated by the inventory are not specific enough to be considered as green patents, increasing the probability of incurring Type I errors.

EPO's Y02/Y04S tagging scheme

The Y02-Y04S tagging scheme was developed by experts from within the EPO with the help of several external partners that also provided specialists to evaluate the technologies, including the European Commission and the UNFCCC, and revised by several experts from UN organizations, NGOs, the OECD and industry and business associations, researchers and academics. According to Veefkind et al. (2012), the Y02 and Y04S tagging schemes are part of a parallel scheme using the same hierarchy of the CPC, but it does not exclude or replace any existing codes from the original IPC classification. It was inspired by an earlier initiative, the Y01N, which aimed at tagging patents belonging to nanotechnology, another field in which the technologies might be scattered through a wide range of IPC codes. The tagging classification was formally introduced in a report from the EPO in partnership with the United Nations Environment Programme (UNEP) Economics and Trade Branch and the International Centre for Trade and Sustainable Development (ICTSD) entitled "Patents and Clean Energy: Bridging the Gap Between Evidence and Policy" and originally only incorporated two subgroups, namely Y02E and Y02C, expanding to the other groups in 2012 (see Table 1).

[8] The topic "Administrative, Regulatory or Design Aspects" includes IPC codes such as G06Q (Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for) and G08G (Traffic control systems).

The main criteria for classification as a CCMT is that the technology or technological field has potential for reducing greenhouse gas emissions, and such potential is defined by technical and objective features of the technology. As for the Green Inventory, these technical features were based on the UNFCCC's inventories of climate change mitigation technologies, as well as policy documents from the European Commission, technology reports from the IPCC, and from the feedback of the experts in each field (Veefkind et al., 2012). The tags are also constantly updated by running new search algorithms designed by those expert examiners, which might include or exclude patent documents of the list - the last updates in the database were done in October-December 2017. Currently, the Y-tags include a wide range of technological fields and subfields (over 1300 individual Y-tags) that are grouped into seven major fields (See Table 1).

The Y02 group corresponds to the "technologies or applications for mitigation or adaptation against climate change". The Y04S tags represent a special subgroup, smart grid technologies, whose green nature might be controversial. The EPO states that the group do represent technologies that "play a major role in the efficient, sustainable operation of power systems" (EPO, 2016, p. 14), arguably optimizing the use of green technologies, i.e. improving the use of electric vehicles or connecting renewable power sources to the grid more efficiently. However, the organization also states that only around "two thirds of the Y04S categories relate to climate change mitigation technologies (CCMT)" (ibid, p.14), and that the green patents in the subgroup would often also be coded under Y02 subgroups such as Y02B, Y02E or Y02T. Thus, adopting the Y04S might increase the occurrence of Type II error.

As Veefkind et al. (2012) states, the tagging scheme also presents some of the challenges that are common to all definitions of green technologies as discussed in Section 1.1 and even if the positive environmental impact "is contested for some sectors (e.g. biofuels, with an associated ethical and technical debate) they may still be included, if they are on the UNFCCC negotiation table and there is a need to inform the public about their relevance as CCMT and their ownership" (p. 107). The authors also discuss the context-dependent nature of the perception of what is green technology, as not necessarily "all technologies included in the Y02 scheme are ecologically sound or 'green' etc., as they may have other detrimental aspects, which are not part of our considerations (e.g. nuclear energy) or may be considered CCMTs under given circumstances only" (p.107).

Table 1 - Main subgroups of EPO’s Y02/Y04S tagging scheme (as of February 2017) (EPO, 2013)

Sub-group	Title	Description
Y02B	Climate change mitigation technologies related to buildings, including housing and appliances or related end-user applications	Integration of renewables in buildings, lighting, HVAC (heating, ventilation and air conditioning), home appliances, elevators and escalators, constructional or architectural elements, ICT, power management
Y02C	Capture, storage, sequestration or disposal of greenhouse gases (GHG).	CO2 capture and storage, also of other relevant GHG
Y02E	Climate change mitigation technologies in energy generation, transmission and distribution	Renewable energy, efficient combustion, nuclear energy, biofuels, efficient transmission and distribution, energy storage, hydrogen technology
Y02P	Climate change mitigation technologies in the production or processing of goods	Metal processing, chemical/petrochemical industry, minerals processing (e.g. cement, lime, glass), agroalimentary industries
Y02T	Climate change mitigation technologies related to transportation	e-mobility, hybrid cars, efficient internal combustion engines, efficient technologies in railways and air/waterways transport
Y02W	Climate change mitigation technologies related to wastewater treatment or waste management	Wastewater treatment, solid waste management, bio packaging
Y04S	Smart grid technologies	Power networks operation, end-user applications management, smart metering, electric and hybrid vehicles interoperability, trading and marketing aspects

Despite its limitations, it is important to highlight the improvements of this classification scheme in relation to those that rely purely on the original IPC codes, especially for those fields that are spread across several IPC groups (e.g. improvements in production processes). For some CCMTs, groups of IPC codes can be used to represent a technological field (e.g. wind energy). However, some CCMTs might be scattered across multiple IPC sections and mixed with other, non-green technologies. That is the case of carbon capture technologies, for example, that can be represented through the IPC code B01D53/62 (“Separation of gases or vapours; Recovering vapours of volatile solvents from gases; Chemical or biological purification of waste gases, e.g. engine exhaust gases, smoke, fumes, flue gases, aerosols – Carbon oxides”) and at the Y02 subgroup as Y02C10 (“CO2 capture or storage”). The Figure 1 shows that there is little overlap between the patents containing these two codes, and the second group contains more documents than the first.

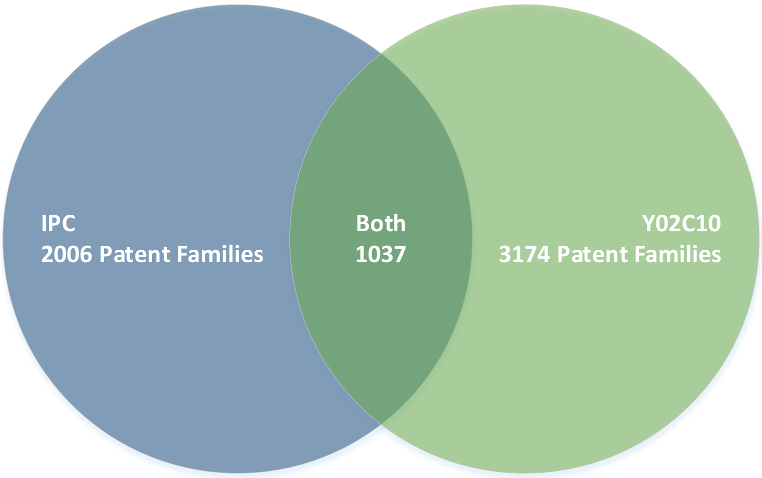


Figure 1- Comparison of datasets retrieved through the IPC (B01D53/62) and the new EPO Classification scheme Y-tags (Y02C10) as April 2010.Source ICTSD (2010).

Similarly, Kapoor et al. (2015) compares the wind energy patents obtained by using the IPC group F03D and the Y02E 10/7 group from 2001 to 2010. The authors conclude that the Y-tags returns more results than using the IPC codes. More specifically, they found that Y02-based searchers returned 32% more patents than when using IPC codes for US patents, 16% more for EPO patents, and 12% for Chinese patents. Not everyone agree that this is the best method: Kessler and Sperling (2016) reports that the group “Y02E 50”, for instance, which is related with technologies for the production of fuel of non-fossil origin, does not capture methods for extracting saccharides from cellulose, but it is captured through the IPC group “C12P 19”.

OECD’s ENV-TECH

The OECD ENV-TECH correspondence of environmental technologies was created by the OECD Working Party on Integrating Environmental and Economic Policies (WPIEEP) and the Working Party on Climate, Investment and Development (WPCID), and combines IPC codes and CPC (Y02) codes, thus relying mostly on the already mentioned classification from the EPO

(Haščič & Migotto, 2015). The selected IPC/CPC classes are grouped into 80 "technological fields" that are connected to policy objectives, including human health impacts of environmental pollution, addressing water scarcity, ecosystem health, and climate change mitigation.

The coverage of the correspondence is thus broad. Therefore, including all fields under the catch-all term of green can be misleading depending on what that definition includes (see above).

Societal Grand Challenges (SGC) and different correspondences

In short, there are several overlapping correspondences between patent classes and targeted technologies that can be construed in broader or narrow terms as 'green'. A recent report (Frietsch *et al*., 2016) has attempted to synthesize existing classification systems (based on IPC and CPC nomenclatures) and to align them in relation to Societal Grand Challenges. This work, which was carried by Fraunhofer ISI for—and with the active contribution of— the EU Commission[9], undertook a broad approach and encompasses the correspondences reviewed above. One objective was to provide a way for patent-data to be used to assess the impact of EU funding instruments to address these challenges.

The categorization system of Societal Grand Challenges (SGCs) addresses a range of 'Grand Challenges'[10]. In doing so, its coverage of 'green technologies' may be seen as comprehensive. However, these green technologies are spread throughout the SGC compendium. Technologies that may be considered 'green' are primarily to be found under the headings of Bioeconomy, Energy, Transport, and Climate. It should be emphasized that the SGC report synthesize all previous lists to compose the groups of IPC/CPC codes related to each SGC, as well as other external sources. It shows how the different approaches, including ENV-TECH, WIPO, and the

[9] A co-author of the report, Koen Jonkers, works for the EU Commission

[10] The headline areas are: 1) Health, demographic change and well-being [HEALTH]; 2) Food security, sustainable agriculture, marine and maritime research, and the bio-economy [BIOECONOMY], 3) Secure, clean and efficient energy [ENERGY], 4) Smart, green and integrated transport [TRANSPORT], 5) Climate action, resource efficiency and raw materials [CLIMATE], 6) Secure societies – protecting the freedom and security of Europe and its citizens [SECURITY].

Y-tag schema, map to the underlying IPC and/or CPC classes, while also expanding these existing nomenclatures in a limited number of cases (e.g. transportation) based on its longstanding work on patent correspondences.

There are some potential benefits and some potential costs associated with trying to use the comprehensive classifications found in the SGC Report to target ‘green technologies’. In short, there is no one-size-fits all definition of ‘green technologies’. One advantage of the SGC is that the range of categories can be scaled up to accommodate a broader (e.g. including nuclear technology or technologies to improve the performance of combustion vehicles) or a narrower definition (e.g. only renewable energy generation) depending on the use-case. Another advantage is that it helps to bridge the IPC and CPC based systems. This is important as patent classification systems are evolving internationally and are generally moving away from the IPC to CPC (ECLA based) systems.

There are important potential downsides to using all nominally relevant classifications in the SGC report. These will be illustrated below. In short, implementing all current classification systems that are synthesized in the SGC report (including the WIPO Green Inventory) would tend to increase the probability of incurring in the Type I error depending on how stringent one defines ‘green’. Additionally, there are cases in which the SGCs may overlap because they are defined by same IPC codes. This can easily lead to confusion if the user does not have clear inclusion and exclusion rules.

Going forward, this report will therefore focus on the narrow definition based closely on the Y-tag system. The Y-tag system will act as a baseline. Below, we will compare this baseline against a broader set of ‘green’ categories based on the correspondences in the SGC report.

1.2.2 Use of green patent classification schemes in the literature

In order to illustrate the use of each of these classification schemes in the academic literature, we conducted a search on Scopus and Google Scholar using “green patent*”, “Y02*”, “Green

Inventory” and “Env-tech” as keywords[11]. The papers were then screened to assess which classification system(s) were used in each of them. The summarized results can be seen in Table 2 (the full list of papers and the assessment of which classification scheme they have used is included in Appendix A).

While some develop their own classification (e.g. Carrión-Flores & Innes, 2010; Costantini et al., 2015; Dechezleprete et al., 2011, Johnstone et al., 2010), most papers adopt one or more of the classifications described. The most widely used classification is the WIPO’s Green Inventory, adopted by 22 papers out of 45, followed by the OECD Env-Tech (9 papers) and the EPO Y-tags (7 papers). The Fraunhofer ISI’s list of IPC classes for Societal Grand Challenges (2016) has so far only been adopted by one paper. Keyword searches were used in 9 papers in the sample. Some studies also combined two or more classification systems to define the group of green patents: the ENV-TECH and the Green Inventory, for instance, were adopted in 5 papers.

Table 2 – Use of different types of green patent classification schemes in the literature

	OECD ENV-TECH	**WIPO Green Inventory**	**EPO Y-tags**	**Fraunhofer ISI**	**Keyword search**	**Other**
Number of papers	9	22	7	1	9	12
Shares	20%	49%	16%	2%	20%	27%

Note: Total sample counts 45 papers identified by using search parameters: “green patent*”, “Y02*”, “Green Inventory” and “Env-tech” in Scopus and Google Scholar.

Although the Green Inventory is the single most widely used system, the papers that adopt this classification scheme are slightly older than the ones adopting the ENV-TECH and the Y-tags. Many papers also adopt other refining tools such as language processing and text analysis to filter the results.

The results of this quick assessment emphasize several features about these correspondences already touched up. To recap, the approaches attempt to create a ‘cross-walk’ between the

[11] The search was conducted in April 2018. Only academic papers in peer-reviewed journals were considered.

detailed nomenclature of patent-classes and the less precise category of ‘green technologies’. This inherent difficulty becomes compounded by the fact that the definition of ‘green technologies’ is neither black-and-white nor homogeneous: the definition may be highly ambiguous in specific cases while being highly heterogeneous in sum. What ultimately is construed as ‘green’ depends on a range of subjective factors (the viewpoints of the patent examiner, the individual researcher or the policymaker who sets the correspondence or who uses it to assess a given technology) as well as a set of more objective considerations, for example, how the patented technology in fact eventually is used, what other components are combined (very few patents solely express novelty in ‘green’ classifications), how up-to-date the correspondence is given that technologies evolve faster than the categorizations, etc. These aspects are reflected in the literature, where the questions of what is green and how green exist on something of a sliding scale.

The different systems are thus not exact equivalences. For example, the SPC is essentially an updated synthesis (and a recast) of previous attempts while the EPO Y-tags system is a system initially developed together with patent examiners with a narrower scope. In addition, the cited approaches have been in circulation for a longer (e.g. OECD) and for a shorter (SGC) length of time, and the difference will affect the length of citation trails. Still, this quick assessment gives an indication of the traction of different approaches. The important lesson from the comparison is that there are different correspondences with more or less different objectives that different users use to lesser or greater degrees.

Given the inherent interpretative flexibility built into ‘green patenting’, this report will showcase a restrictive and standard definition of green patenting. Our overall purpose is to study the regional contribution to ‘green patents’ across four countries and across 15 years. The selection in our report is to use a definition that promises a stable and level foundation for comparison across countries and across time. The choice of a more restrictive definition of green technologies helps to reduce Type1 errors, which are more serious when setting out to establish a baseline for comparison. To this end, the report will focus on the EPO (Y02)-tags to discriminate between green and non-green technologies and we will focus on patent-families with at least one patent application filed at the European Patent Office (EPO) in 2000-2014. This is very close to the widely used OECD measures (see also below).

1.2.3 EPO Y-tags versus other Green Technologies based on SGC categories

The working definition of ‘green patents’ that will be showcased through the rest of the report will be presented in the next section. Before defining that baseline population, this section compares a narrower definition, based on the Y02 tags, from a broader one, based on a correspondence to several categories (Health, Food & Bioeconomy, Energy, Transport, and Climate) from the Societal Grand Challenges Report. This comparison highlights how definitions may influence results, while also allowing us to discuss some tradeoffs associated with different approaches.

In order to appreciate how different classification systems cover different aspects of the green economy we compare Fraunhofer ISI categorisation of SGC with EPO’s Y-tags (See Annex D) Table 3 compares the baseline of EPO Y-tags with the wider population of patents that (also) allocate to nominally relevant (i.e. ‘green’) categories from the Social Grand Challenge (SGC) report. It illustrates how they overlap for the population of European patent families with Nordic inventors between 2000-2014[12]. All green class-ids (SGC and/or Y-tags) are collected at the level of the patent family before duplicates are removed. The patent family is then put into one of three mutually exclusive groups: (i) Only SGC categories, (ii) Only Y-tags, and (iii) an overlap of both. In this exercise, the individual class-categories (e.g. fuel cells) are fractionally counted (the inventors are not).

An individual patent application (family) may involve multiple patent-classes which in turn may map both to Y-tags and/or to other. The table fractionally counts the ‘green categories’ (e.g. climate sgc) for each application (family). Individual patent applications (counted once at the level of families) can be classed in as many as 6 different green categories (in addition to multiple non-green classes). If an individual application allocates to two categories— for example one that maps to Y-tags, such as ‘energy sources y02e’, and another that maps to other SGC

[12] Definitions: extracted from PATSTAT 2018b. families involving: 1. Nordic inventors (including Icelandic) 2. 'green technologies' (either via SGC and/or Y-tags), 3. with a family member as EP-A and 4. for filing dates in 2000-2014

categories, such as ‘climate’ – then that application would be placed in the overlapping category of SGC and Y-tags, with half going to each category.

Table 3: Patent Families according to SGC and/or to EPO Y02-tags categories using fractional counts: Nordic EP applications 2000-2014 (N=15.138 patent families)*

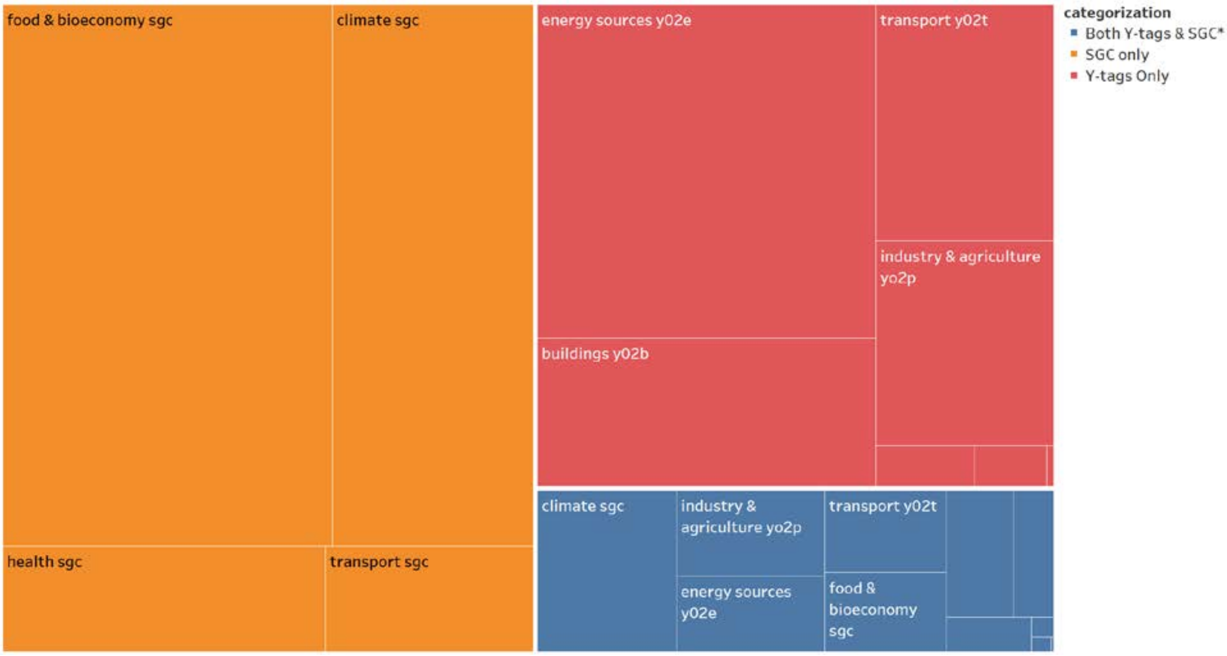
		2000-2004	2005-2009	2010-2014	Total
SGC only	climate sgc	726	728	979	**2 434**
	food & bioeconomy sgc	1 435	1 230	1 321	**3 986**
	health sgc	404	203	154	**761**
	transport sgc	239	137	114	**490**
Y-tags Only	buildings y02b	203	349	574	**1 126**
	energy sources y02e	257	806	1 467	**2 530**
	gh-gass y02c		5	2	**7**
	industry & agriculture yo2p	218	246	351	**815**
	transport y02t	174	301	465	**939**
	waste/wastewater y02w	16	21	29	**66**
Both Y-tags & SGC*	buildings y02b	2	5	3	**10**
	climate sgc	119	157	236	**511**
	energy sources y02e	42	85	130	**256**
	food & bioeconomy sgc	44	61	114	**218**
	gh-gass y02c	10	24	32	**66**
	health sgc	2	2	2	**7**
	industry & agriculture yo2p	61	87	140	**288**
	transport sgc	29	66	99	**193**
	transport y02t	40	59	127	**226**
	waste/wastewater y02w	37	40	41	**118**
	N	**4 075**	**4 638**	**6 425**	**15 138**

Source: Compiled based on Patstat2018b.
* An individual patent application (family) may involve multiple patent-classes which in turn may map both to Y-tags and/or to other. The table fractionally counts the ‘green categories’ (e.g. climate sgc) of each application (family).

The table illustrates that the two categorization systems are largely complementary. In nominal terms, the two classifications systems overlap most clearly in area of ‘green transportation. The area of climate technologies in the SGC category includes subcategories (water and waste-water, air quality management, etc) that can be linked to areas of the en-tech classification. Indeed a quarter (N=1900) of the families with y-tags (7500) overlap with SGC categories.

Figure 2 illustrates the relative magnitudes that allocate to either the SGC system (orange), EPO Y-tags (red) or both (blue).

Figure 2: Comparison between SGC and EPO Y-tags: Nordic EP applications 2000-2014 (N=15.138 patent families)*



Source: Patstat2018b.
* A patent family is counted once. Categories for y-tags, sgc, and both ytag & sgc are mutually exclusive.

In general, a non-discriminatory application of SGCs is clearly broader than the Y-tags. More than half (51%) of the patent families in the table are only found in the SGC categories. The aggregate categories appear to be overly broad for purposes of defining green patents for most if not all use-cases. For example, the area of ‘food and bioeconomy’ includes some categories (e.g. food and pulp & paper) where green credentials are debatable. The SGC area of health, which includes bio-tech, is arguably an imposter in this list. A closer inspection of subcategories would therefore be called for in order to firm up a solid-population that includes both the SGC and the EPO Y-tags.

It is clearly useful to derive a composite list based on these two categorisation systems. While this is done, it is advisable to stick to the y-tag system in order to explore the baseline for green patenting in the Nordic Countries. This exercise illustrates the need to balance Type1 and Type2 considerations. A broad application of SGC categories clearly leads to fairly clear Type1 errors: however, the Y-tags approach might lead to Type2 errors depending on how narrow or broad the definition of ‘green’ technologies we use is. Specific inclusion and exclusion rules are however necessary in order to more accurately gauge the level and orientation of ‘green’ patenting.

1.3 Data sources and methods

In this light, the report will implement a more restrictive interpretation of green patents. The definition used in the presentation below is based on EPO PATSTAT offline database (Version October 2017).

(i) What: The EPO’s Y-tag system is used to differentiate between green and non-green patent applications.

(ii) Where: A patent family involving at least one application filed at the European Patent Office (EPO) between 2000 and 2014.

(iii) When: First-filing date in the 15-year period 2000-14.

(iv) How: The approach does not use fractional counts to discriminate between green and non-green patent applications.

The rationale is that EPO is an important patent office for Nordic companies and other type of actors, when they decide where a potential granted patent should be protected. We are moreover interested in the geographical distribution of patenting across regions, and since NUTS codes are attributed to patents filed at the EPO more consistently than patents filed to national patent offices, we have limited our mapping exercise to the EPO register for purposes of this. Consequently, we drop patent applications that are only filed to national patent offices. This exclusion rule effectively removes around 6,000 applications involving Nordic inventors that are filed at the domestic offices but not at the EPO. This exclusion disproportionately affects Norwegian patenting since Norway first became a full-member of the EPO system in 2008, which is in the middle of the reference period here.

However, for the total sample (Denmark, Finland, Norway and Sweden) we find that the distribution of Y02 codes is similar for patents filed at the EPO compared to patents filed at the national offices (see Figure 3). This justifies the use of the first group (EPO) as proxies of the patent portfolio for each country and region. However, when interpreting the geographical distribution of patenting activity it is important not to read the numbers as an absolute expression of all patent activity in the respective regions but see the numbers as proxy for knowledge generation within specific technology areas. Similar figures for each country, can be found in Appendix B (Figure 34-Figure 37).

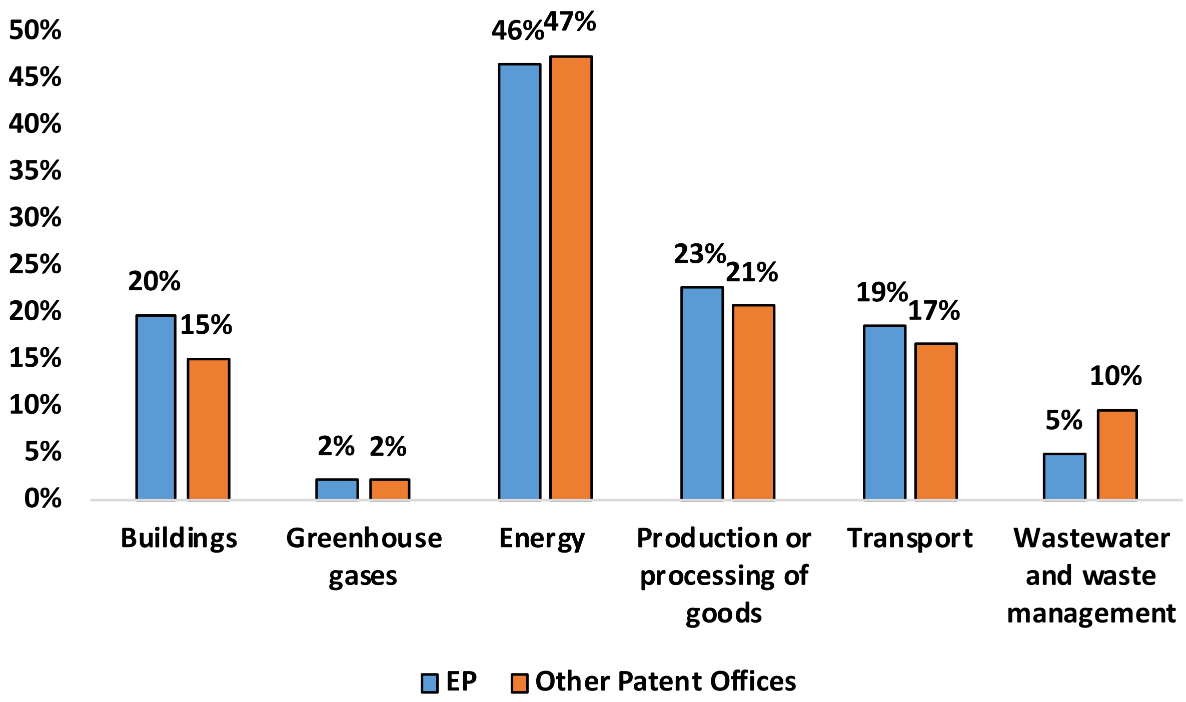


Figure 3- Distribution of patents among the six technological areas for EPO and other Patent offices – Nordic countries

1.4 Descriptive data and measures

The total population is defined by Family-ID in the EPO register and regionalised based on inventors' address. We use individual family-id instead of patent applications. Family-ids group one or more similar patent applications filed to different patent offices throughout the world. Inventors often patent their inventions in many patent offices in order to protect them in important markets. Hence, if we used patent applications, we would risk counting an invention several times.

Patent families have been allocated to each region based on inventors' address and fractional counts. We use inventors' address (and not applicants' address) because it is assumed that these are geographically closer to where the knowledge behind the patent application has been produced. Whereas using the applicant address risk of ascribing large companies' patent activity at different labs or research units to the headquarter. 'Fractional counts' mean that if one patent family have inventors residing in, for example, three different regions, the patent family has been ascribed with one third to each region. The reason for fractional counts based on regions, is that we want to avoid over counting of patent activity when inventors reside in neighboring regions but in fact commute to the same workplace. Since many of the Nordic regions are relatively small it is more likely people commute across regional borders and it is therefore likely that the risk of over counting by not using fractional count would be high. However, this means that when interpreting the numbers, one should be aware of regional neighbor-effect, i.e. that some knowledge production is allocated to neighbor regions instead of the region where the workplace is located.

In some cases, patents have been invented by inventors residing regions in two different countries and a patent family may therefore be split according to the fraction between the two countries, e.g., 2/3 to Denmark and 1/3 to Sweden. As a consequence, a straight count of patent families within a technology area at the country level are marginally larger than the sum of the count based on fractional counts within the same technology (see an overview of the differences in sums at the country-level by using fractional counts at different levels in Appendix C, Table A 15).

We have, on the other hand, not used fractional counts of CPC-codes, since the aim of the mapping is to show knowledge activities within different technology areas (i.e. CPC-codes) across regions. Therefore, if a patent family is categorized with two different CPC codes (e.g., in the energy sector and construction sector) both CPC codes will be counted as 1 for each region. In the case of inventors residing different regions it will then be fractioned based on the number of regions involved in the patent.

The consequence of adopting non-fractional counts for CPC-codes is that we will over count patent families, which falls within more than one technology code. Moreover, the more technology areas a patent family covers the more weight it will be given. So a patent family that covers many CPC-codes will count more than a patent family that only covers one or few CPC-codes. Since we are interested in mapping knowledge activity within technology classes and subclasses, we believe using non-fractional counts of CPC codes will give the most accurate picture of where knowledge activity takes place.

Table 4 and Figure 4 show the total patent count, family count and the degree of regionalization in the Nordic countries. On average, the patent count is 2.5 times larger than the Patent family count, indicating that each patent family covers on average 2.5 patent application. The degree of regionalization is acceptable for all countries (between 96-99%).

Table 4: Total patent count, patent family count and regionalization degree across Denmark, Finland, Norway and Sweden

	Patent count					**Patent families**					**Regionalization degree**			
	DK	FI	NO	SE		DK	FI	NO	SE		DK	FI	NO	SE
2000-2014	6048	4495	2181	6070		2567	1474	600	2688		98%	99%	96%	98%
2000	144	134	83	223		42	36	13	77		100%	100%	100%	100%
2001	128	141	79	225		41	42	18	89		100%	100%	100%	100%
2002	176	182	84	216		52	47	16	88		100%	100%	100%	99%
2003	224	224	102	238		73	68	21	105		100%	100%	100%	100%
2004	208	212	95	256		66	58	27	107		100%	100%	100%	100%
2005	233	218	139	292		78	61	35	136		100%	100%	97%	100%
2006	288	247	156	308		91	75	41	131		98%	100%	95%	100%
2007	348	241	176	360		145	63	49	151		100%	100%	98%	100%
2008	534	329	208	478		222	98	57	191		98%	100%	93%	99%
2009	551	365	215	498		228	117	58	218		99%	99%	93%	100%
2010	696	445	228	483		324	142	73	214		97%	99%	94%	99%
2011	732	459	216	675		331	163	69	322		96%	99%	91%	99%
2012	740	467	166	567		334	174	50	266		98%	99%	100%	100%
2013	528	423	125	690		252	165	40	329		98%	100%	100%	99%
2014	520	409	113	563		289	167	36	266		96%	96%	100%	87%

Source: EPO PATSTAT Offline, EP Register, Oct. 2017

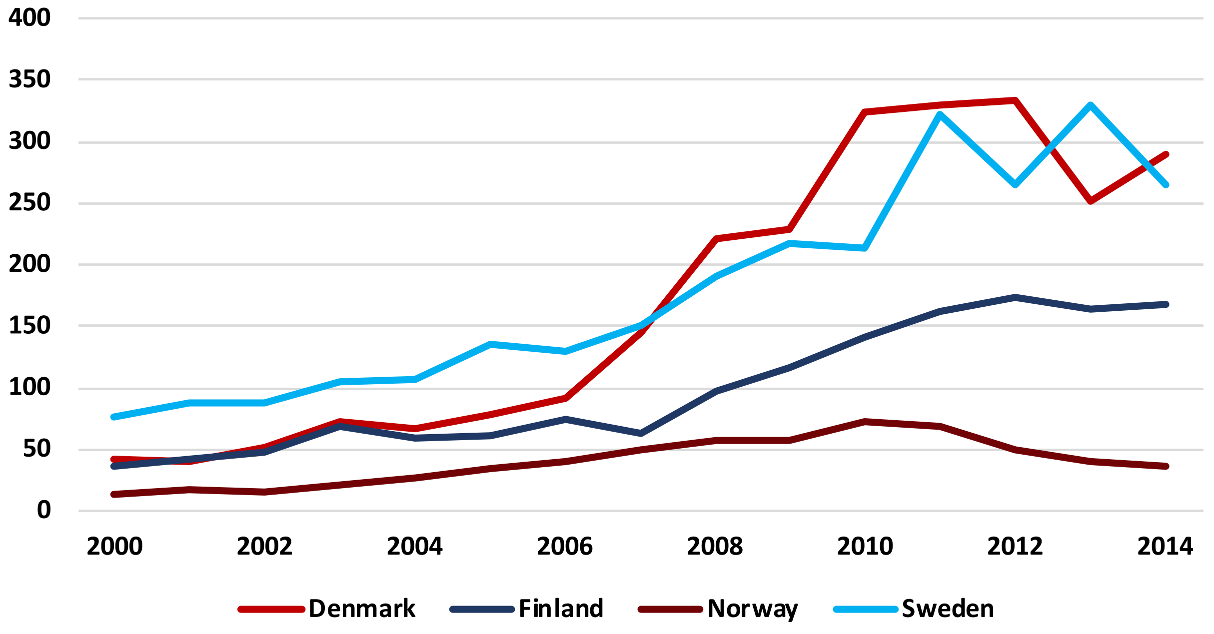


Figure 4 Total patent family count in Nordic countries, Patent Family ID, based on fractional counts Total Patent family count per country - 2000-2014

1.4.1 Relative Technological Advantage (RTA)

Besides the descriptive analysis based on the attribution of patent family counts to each region, a Relative Technological Advantage (RTA) is calculated in order to measure the relative strengths of regions patent applications within specific technology classes relative to other technology classes (Malerba & Montobbio, 2003). The formula for the RTA is given below:

$$\mathrm{RTA}_{ij} = \frac{\left(\mathrm{P}_{ij}/\sum_i \mathrm{P}_{ij}\right)}{\left(\sum_j \mathrm{P}_{ij}/\sum_i \sum_j \mathrm{P}_{ij}\right)}$$

where P_{ij} represents the number of patent families from technology *i* on the patent family portfolio of region *j*. The RTA compares the share of a given technology *i* within the portfolio of region *j* with the share of the same technology for the whole sample. In order to attenuate the effects of the larger regions in the sample, an average of all regions' share on the denominator instead of summing the patents is adopted:

$$\mathrm{RTA}_{ij} = \frac{\left(\mathrm{P}_{ij}/\sum_i \mathrm{P}_{ij}\right)}{\frac{1}{n}\sum_j\left(\mathrm{P}_{ij}/\sum_i \mathrm{P}_{ij}\right)}$$

The RTAs used and shown in each country section have been normalized by using the formula: (RTA-1)/(RTA+1), which is a symmetric measure ranging from -1 to 1. , If [$-1 < RTA < 0$], the region *j* has a smaller share of patents on technology *i* than the sector average and the closer to -1, the less specialized is the region on such technology. In contrast, if [$0 < RTA < 1$], a region is more specialized on the technology than the average. A $RTA = 0$ indicates that the region *j* follows the average patenting activity of the whole sample for technology *j*. When analyzed over time, the measure is also able to capture changes in opportunities and persistence in regions' strategies.

In Table 6 (and in Table A10 to Table A14 in Appendix C) the RTAs have been shaded depending on how strong a technological specialization the measure reveals, to give a better overview across the regions and countries. The divides are made as: From 0 to 0.2; Between 0.2 and 0.5, and above 0.5, where the latter reveals strong technological specialization. The last column in the Tables, show the count of cells larger than 0.

Note, that these measures are in some cases calculated based on very low counts, which makes the RTA-measure very uncertain. Therefore, please refer to the absolute counts in Table A1 to Table A9 in Appendix C.

1.4.2 Herfindahl-Hirschman index

In addition to the RTA, a measure of concentration is used to indicate which regions have more concentration of the patents in specific technological areas. The Herfindahl-Hirschman index (HHI) (Herfindahl, 1950; Hirschman, 1964), typically used in industrial economics and international trade literature to measure market concentration and specialization, is adopted as suggested by Malerba & Orsenigo (1997). The index is described as:

$$\mathrm{HHI} = \sum_{i=1}^{I} b_i{}^{\alpha}$$

Where *b* is the share of each technology *i* in the overall patent portfolio (for each region) and α represents the weight given to each technology, which is α = 2 as standard. The index can also be used as a measure of diversification (Palan, 2010), since specialization = 1 – diversification. Therefore, the closer to 0, the more diversified is a region, i.e. the region has a more balanced portfolio distributed through all technologic groups.

2. Geographical Distribution of Climate Change Mitigation technologies across the Nordic countries

This section compares the patenting activity across the six CCM technology areas and their sub-groups across the four Nordic countries. In the next sub-sections we map the distribution of green technology development across regions within each of the four Nordic countries: Denmark, Finland, Norway and Sweden. In this section the focus is on the country level.

Figure 5 below presents:

a. the total number patent applications at the EPO by country (bars, left axis),
b. the share that a selection of “environment-related technologies" account for (lines, right axis) of each country’s European patenting activity.

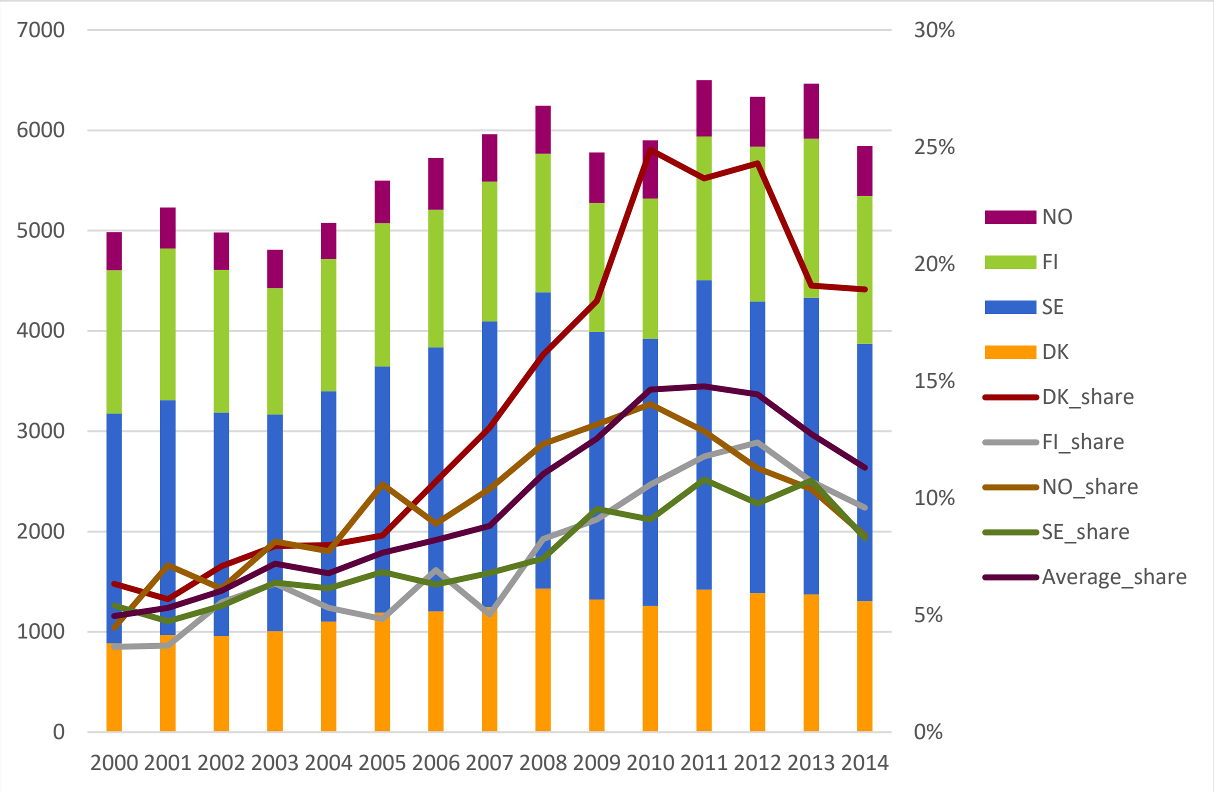
Figure 5 indicates that the four Nordic countries applied (in terms of inventors, fractional counts) for roughly 6,500 individual patents at the EPO in 2013 (year of application). This preliminary measure provides the basis to introduce a number of dimensions about green patenting that we will review in the following country-specific sections. The first dimension is that patent propensity varies from country to country. The propensity to patent differs across countries for reasons that may have more to do with structural factors than with the relative strengths of the domestic innovation system[13]. In this context, we see that the Nordics differ dramatically in terms of the overall number of patents each applies for in Europe. Sweden accounts for a disproportionately large share (roughly 45%) while Norway for a disproportionately small share (roughly 8%) of the Nordic patents in Europe.

[13] The importance of the market in which the patents are sought (European in this case) is of primary importance when considering how active domestic firms and other RD&I active entities are in the given jurisdiction. In general, patent counts will be higher for countries with higher shares of larger firms and, more particularly, larger firms that are active in patent-intensive technologies (such as chemicals and pharmaceuticals).

Figure 5 introduces about (European) patenting during the period of study, and that is that the propensity to patent tends to follow the prevailing economic conjuncture. We observe as Nordic patent applications start to fall in total numbers (represented by the vertical bars) after the burst of the ICT bubble in 2000. Nordic patenting subsequently rises towards 2008 before dropping during the financial crises. Again, the annual variations have more to do with characteristics of the lens we use (patent applications) than the innovativeness of the countries in question.

A third dimension that this lens reveals is that the relative share of 'green technologies' differs considerably across countries and across time. According to the often-used OECD measure for green patents "Selected environment-related technologies" (which is closely related to the Y-tags and discussed above) the figure shows a general upward trend. The average share for the four Nordic countries for 2001-2014 is 10 percent, and it more than doubles from 6 percent at the beginning of the period to over 12 percent at the end. Denmark is clearly a special case, with green patents accounting for roughly one of five patent applications in the later years. We should

Figure 5: Patent applications at the EPO (EP-A) for 2001-2014 among four Nordic countries: by country of origin (left axis) and share of 'selected environment-related technologies" (right axis), Source: https://stats.oecd.org



also note that the definition of 'green patents' is not static; it has evolved over the time-period under consideration here and it continues to change[14]. (See also Section 1.1 for a discussion of this).

Table 5 gives an overview of the distribution of patenting activity across the six technology categories (Y02) in the World[15] and the Nordic Countries (only DK, FI, NO and SE) for the period 2000-2014. Denmark (37%) and Sweden (35%) have the largest share of all CCM technology patents patented in the Nordic countries, whereas Finland counts for about a fifth and Norway around 9%, when we look at the whole period. We also see clear differences in how each country specialize in different combinations of CCM technologies. For instance, Denmark's patenting activity in CCM technology is centered on Renewable energy technologies (62%), while 75% of Finland's patented CCM technologies falls almost equally within Building (Y02B), Energy (Y02E) and Production and Processing of goods (Y02P).

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[14] The Y-code system that is used here improves over time. It is currently being updated, and results will therefore differ relative to earlier exercises (see https://www.epo.org/news-issues/issues/classification/classification.html)

[15] In all the tables "World" refers to the total population of patent applications (NB: family-count) filed to the European Patent Office, and not as such the total world-patent applications

Table 5: Distribution of Climate Change Mitigation (CCM) technologies (the six Y02 categories with 4 digits, and total) across the World and the Nordic countries from 2000-2014

	CCM related to BUILDINGS	CCM related to GREENHOUSE GASES	CCM related to ENERGY	CCM related to PRODUCTION OR PROCESSING OF GOODS	CCM related to TRANSPORTATION	CCM related to WASTEWATER TREATMENT or WASTE MANAGEMENT	CCM TECHNOLOGIES, TOTAL	TOTAL PATENT and SHARE of Y02-patents
	Y02B	**Y02C**	**Y02E**	**Y02P**	**Y02T**	**Y02W**	**Y02**	**Total Pt**
WORLD	21598	1850	36656	24644	36293	6275	127316	
Share of Y02	17%	1%	29%	19%	29%	5%		
NORDIC	1444	153	3406	1658	1357	356	8374	
Share of Y02	17%	2%	41%	20%	16%	4%		
Denmark	286	25	1949	662	130	84	3136	11819
Share of Y02	9%	1%	62%	21%	4%	3%		(17%)
Finland	438	11	435	423	256	128	1691	13529
Share of Y02	26%	1%	26%	25%	15%	8%		(7%)
Norway	83	79	315	175	57	44	753	4734
Share of Y02	11%	10%	42%	23%	8%	6%		(9%)
Sweden	681	40	763	442	941	110	2977	25582
Share of Y02	23%	1%	26%	15%	32%	4%		(7%)

Table 6 - Revealed Technological Advantages for 6 categories of Climate Change Mitigation technologies across the Nordic countries

	CLIMATE CHANGE MITIGATION technologies related to BUILDINGS	CAPTURE, STORAGE, SEQUESTRATION OR DISPOSAL OF GREENHOUSE GASES	CCM related to ENERGY	CLIMATE CHANGE MITIGATION TECHNOLOGIES IN THE PRODUCTION OR PROCESSING OF GOODS	CLIMATE CHANGE MITIGATION technologies related to TRANSPORTATION	CLIMATE CHANGE MITIGATION technologies related to WASTEWATER TREATMENT or WASTE MANAGEMENT
	Y02B	Y02C	Y02E	Y02P	Y02T	Y02W
Nordic	0.01	0.11	0.17	0.01	-0.28	-0.07
Denmark	-0.30	-0.91	0.57	0.11	-0.61	-0.73
Finland	0.21	-0.93	0.21	0.19	-0.06	-0.38
Norway	-0.21	-0.24	0.42	0.16	-0.38	-0.49
Sweden	0.15	-0.85	0.20	-0.07	0.30	-0.64

Table 6 shows the measure revealed technological advantage the six categories of CCM technologies across the Nordic countries. All countries have high RTA in CCM related to Energy with Denmark showing the highest score of 0.57. Sweden is the only country with a revealed technological advantage in CCM related to Transport (0.30) and Finland has an RTA on 0.21 in CCM related to Buildings.

In the following sections we map the distribution across NUTS2 regions in the four Nordic regions.

2.1 Geographical Distribution of Climate Change Mitigation technologies across Denmark

The Climate Change Mitigation (CCM) technologies are distributed unevenly across regions in Denmark. Figure 6 shows the Herfindahl-Hirschman index for the five regions in Denmark. It shows that three regions, including the capital region, appear to be fairly diversified with an indicator around 0.30. The Midtjylland (Central Denmark region) and the Syddanmark (Southern Denmark) regions are concentrated within particular CCM technologies with HH indices of 0.49 and 0.58 respectively.

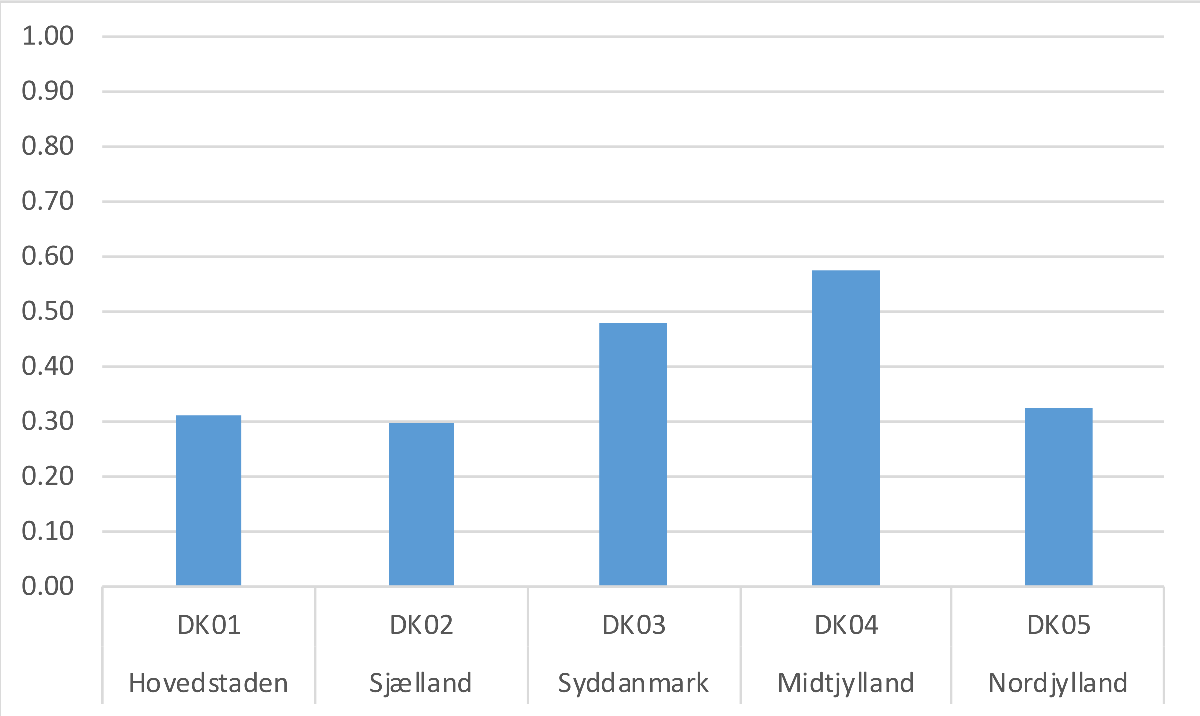

Figure 6 - Herfindahl-Hirschman index – Level of diversification of regions across Denmark

The Midtjylland region and the Syddanmark region also account for a large share of the overall patent applications in Denmark. Figure 7 presents the overall distribution of CCM technology (Y02) in Denmark, and the distribution across different technologies related to wastewater treatment or waste management (Y02W), transport (Y02T), production or processing of goods (Y02P), energy (Y02E) capture, storage, sequestration or disposal of greenhouse gases (Y02C) and buildings (Y02B). The distribution of the almost 3,100 patents show that Denmark is specialized in CCM technologies related to energy and that Midtjylland and Syddanmark accounts for the majority of these (66 percent).

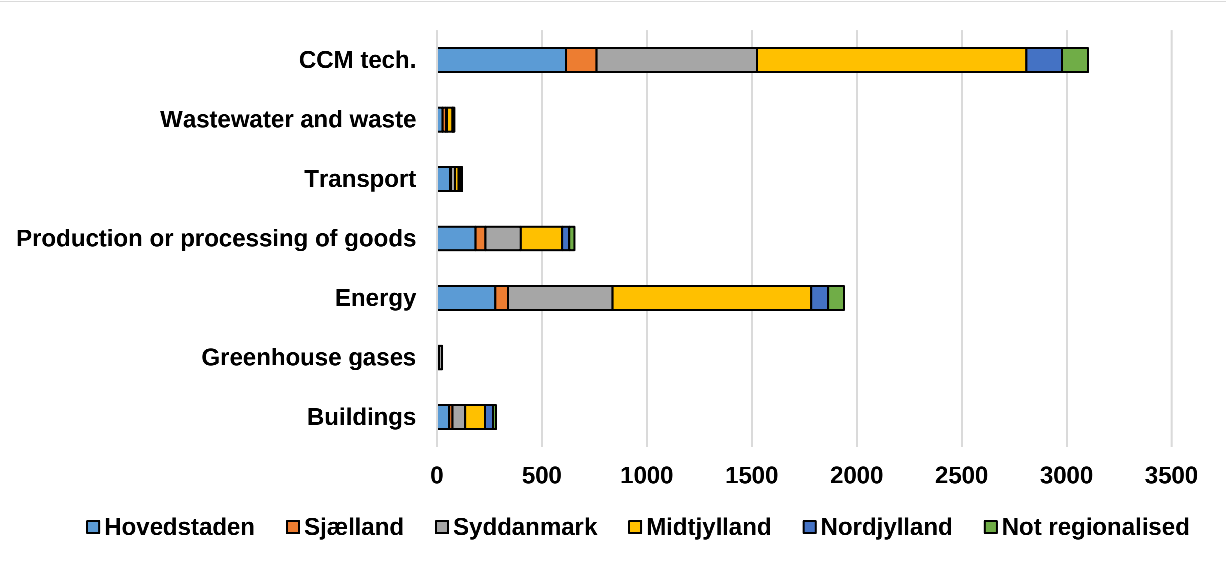

Figure 7 - Distribution of CCM technologies (the six Y02 categories with 4 digits, and total) across regions in Denmark

Figure 8 shows a more detailed distribution of CCM technologies within the energy generation, transmission and distribution category: renewable energy generation (Y02E 10), combustion technologies with mitigation potential (Y02E 20), nuclear energy (Y02E 30), efficient electrical power generation transmission or distribution (Y02E 40), energy generation from fuels of non-fossil origin (Y02E 50), enabling technologies (Y02E 60), and other energy conversion or management systems reducing GHG emissions (Y02E 70).

The more detailed figure reveals that most technologies in Denmark are within the category of renewable energy generation. 79 percent of all Y02E patents are in this category and these are highly concentrated in the Midtjylland region (56 percent) and Sydjylland (29 percent). Hovedstaden (capital region) dominates in technologies related to energy generation from fuels of non-fossil origin, however, this category only accounts for 12 percent of all energy related patents.

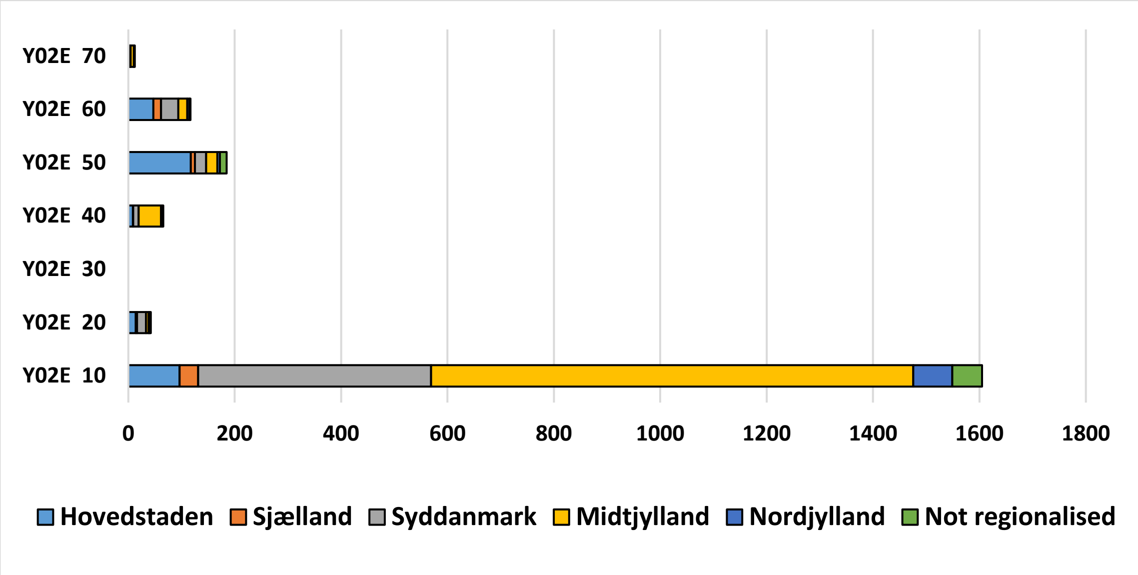

Figure 8 - Distribution of CCM Technologies related to ENERGY (Y02E, and subgroups) across the main regions in Denmark

Figure 9 shows the distribution of CCM patents related to production and processing of goods. and processing of goods including the subcategories of technologies related to metal processing (Y02P 10), technologies relating to chemical industry (Y02P 20), technologies relating to oil refining and petrochemical industry (Y02P 30), technologies relating to the processing of minerals (Y02P 40), technologies relating to agriculture, livestock or agroalimentary industries (Y02P 60), technologies in the production process for final industrial or consumer products (Y02P 70), climate change mitigation technologies for sector-wide applications (Y02P 80), enabling technologies (Y02P 90). The overall category is the second largest of the different CCM technologies in Denmark and it accounts for 21 percent of the total CCM technologies.

Technologies in the production process for final industrial or consumer products (Y02P 70) account for 59 percent of the patents, while 22 percent is within technologies relating to chemical industry (Y02P 20). The geographical distribution of patents reveals differences. Again the largest share of Y02P patents are in Midjylland, but the second largest numbers of patents are in Hovedstaden closely followed by Syddanmark. Most Y02P patents in Hovedstaden are within technologies relating to chemical industry.

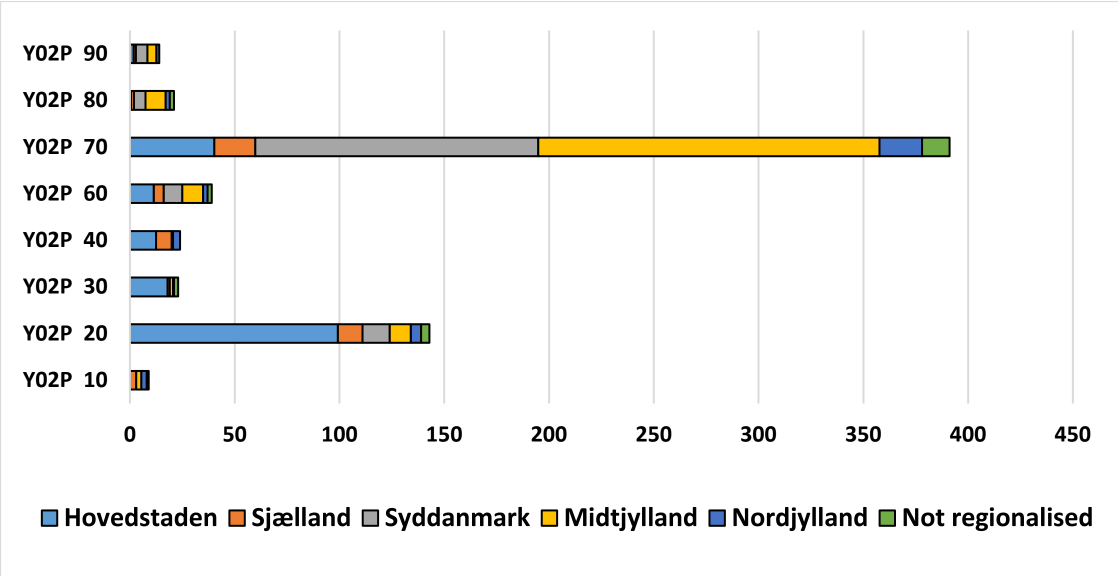

Figure 9 - Distribution of CCM Technologies related to PRODUCTION and PROCESSING of goods (Y02P, and subgroups) across the main regions in Denmark

The technologies related to Transport (Y02T) accounts for less than 4 percent of the total number of CCM technologies in Denmark. The technologies related to road transport (Y02T 10) account for 69 percent of all Y02T patents and most of these are related to the capital region (Hovedstaden), see Figure 10. There are no patents within technologies related to rail transport (Y02T 30), while 19 percent of the Y02T patents are in air transport (Y02T 50), 10 percent in maritime or waterways transport (Y02T 70), and 6 percent in enabling technologies in transport (Y02T 90).

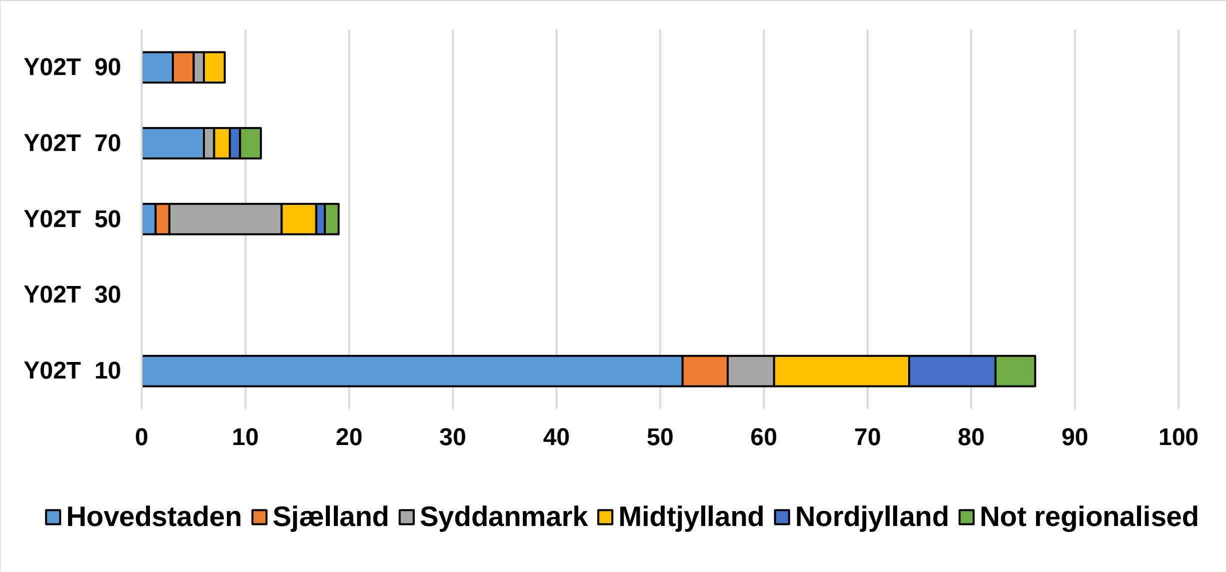

Figure 10 - Distribution of CCM Technologies related to TRANSPORT (Y02T, and subgroups) across the main regions in Denmark

Figure 11 shows the regional distribution of CCM technologies related to buildings (Y02B) and the distribution of subgroups: technologies related to integration of renewable energy sources (Y02B 10), energy efficiency in lightning (Y02B 20), energy efficiency in heating, ventilation or air conditioning (Y02B 30), energy efficiency in home appliances (Y02B 40), energy efficiency in elevators, escalators and moving walkways (Y02B 50), energy efficiency in information and communication technologies (Y02B 60), energy efficiency in end-user side (Y02B 70), architectural or constructional elements improving the thermal performance of buildings (Y02B 80), and enabling technologies in buildings (Y02B 90).

The Y02B category is the third largest of the CCM categories in Denmark. It accounts for 9 percent of the total CCM patents. Figure 11 shows that the patents are more dispersed across categories compared to other CCM technologies. The two largest subgroups are technologies related to integration of renewable energy sources (Y02B 10), 29 percent, and energy efficiency in heating, ventilation or air conditioning (Y02B 30), 27 percent. The majority of patents are in Midtjylland, Hovedstaden and Syddanmark. Within the subcategory of energy efficiency in information and communication technologies (Y02B 60), the majority is located in Northern

Denmark (Nordjylland) which is related to a cluster of firms within wireless communication technologies.

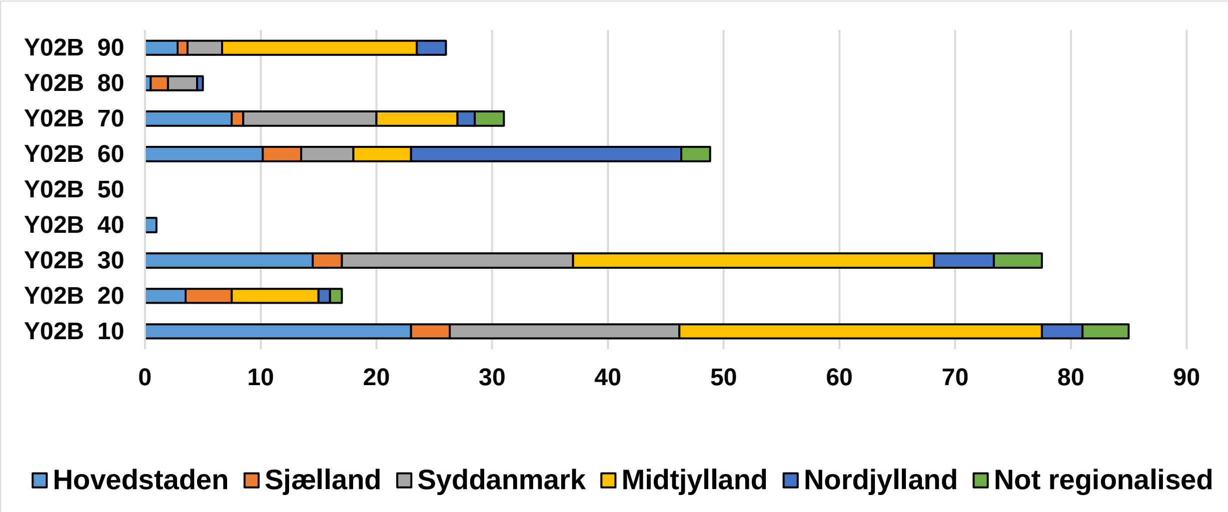

Figure 11 - Distribution of CCM Technologies related to BUILDINGS (Y02B, and subgroups) across the main regions in Denmark

The Revealed Technological Advantages for the six categories of CCM technologies across the five regions in Denmark are shown in Figure 12. The two dominant categories, energy and production and processing of goods, show that several regions are specialized in these technologies. Not surprisingly, Midtjylland and Syddanmark have a strong specialization in technologies related to energy generation, transmission and distribution. For the second largest group Y02P, Hovedstaden and Sjælland (Zealand region) have an RTA of more than 0.2, which indicate a relatively strong specialization, while Midtjylland has a negative RTA (-0.15). However, it should be noted that the specialization of Sjælland is based on a low overall level of patent production in the region, while Midtjylland is still has the highest absolute number of patents in this category in Denmark. Nordjylland has a specialization (0.15) within technologies related to buildings, e.g. housing, house appliances or related end-user applications.

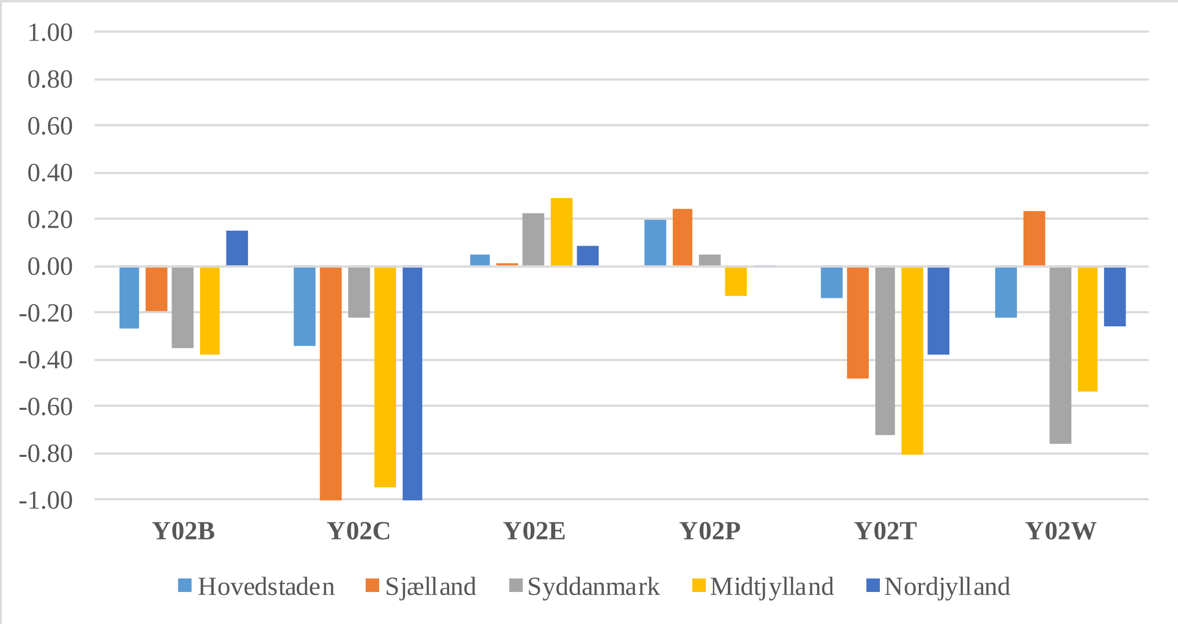

Figure 12 - Revealed Technological Advantages for 6 categories of Climate Change Mitigation technologies across regions in Denmark

2.2 Geographical Distribution of Climate Change Mitigation technologies across Finland

This section describes the distribution of CCM technologies in Finland, according to the sub-categorization of technologies and the regions. Figure 13 shows that two regions, Helsinki-Uusimaa and Länsi-Suomi, contribute to about 74% of all CCM technology patent applications in Finland. In terms of the six sub-group categories within CCM technologies, Finland has more emphasis on Production or processing of goods (Y02P), Energy (Y02E), and Buildings (Y02B) than other categories with similar number of patent applications in the three categories. The relative importance of Helsinki-Uusimaa as the leading region is noticeable in these three categories, whereas Länsi-Suomi contributes with more than half of patent applications within Transport technology.

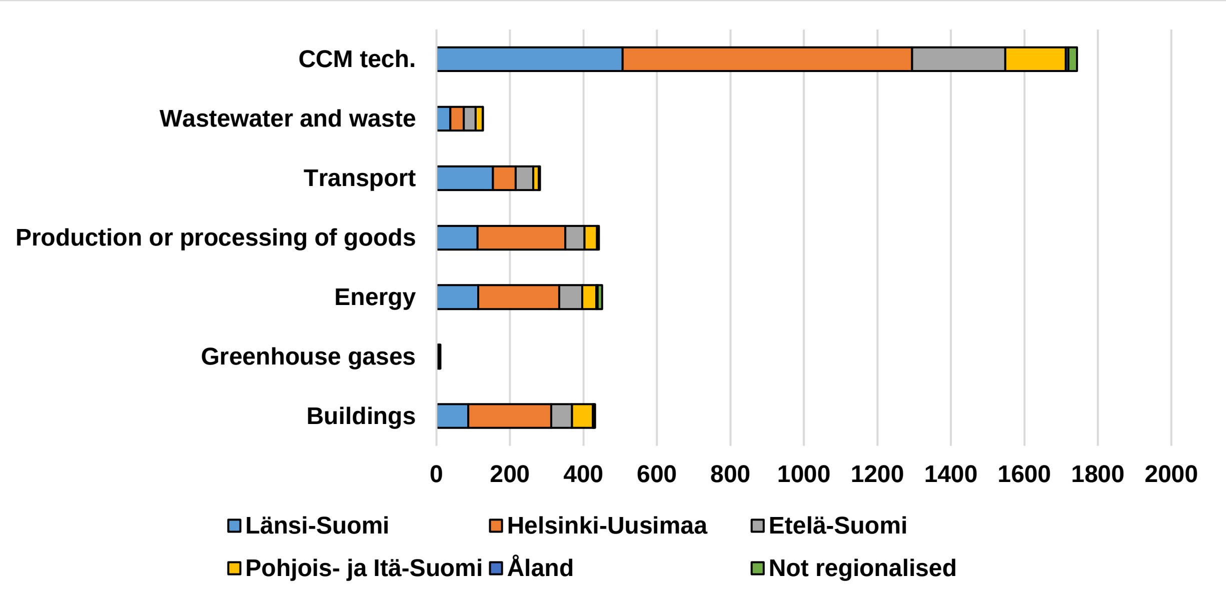

Figure 13 - Distribution of CCM technologies (the six Y02 categories with 4 digits, and total) across regions in Finland

The sub-group Energy is the category that Finland has most patent applications in (429 out of 1658). Within this category, renewable energy generation (Y02E 10) and energy generation from fuels of non-fossil origin (Y02E 50) are the two sub-categories where Finland has the most patents (see Figure 14). For technologies within renewable energy generation, Helsinki-Uusimaa contributes to almost 60 % of knowledge production, followed by Länsi-Suomi with just under 25%. For energy generation from fuels of non-fossil origin, the two regions are still dominating with more than 70% of patents altogether. However, in this category, the share of Etelä-Suomi is almost as much as that of Länsi-Suomi. The regional distribution shows a different pattern in the categories combustion technologies with mitigation potential (Y02E 20) and efficient electrical power generation transmission or distribution (Y02E 40), as Länsi-Suomi outnumbers Helsinki-Uusimaa, which is unlike to the other sub-categories.

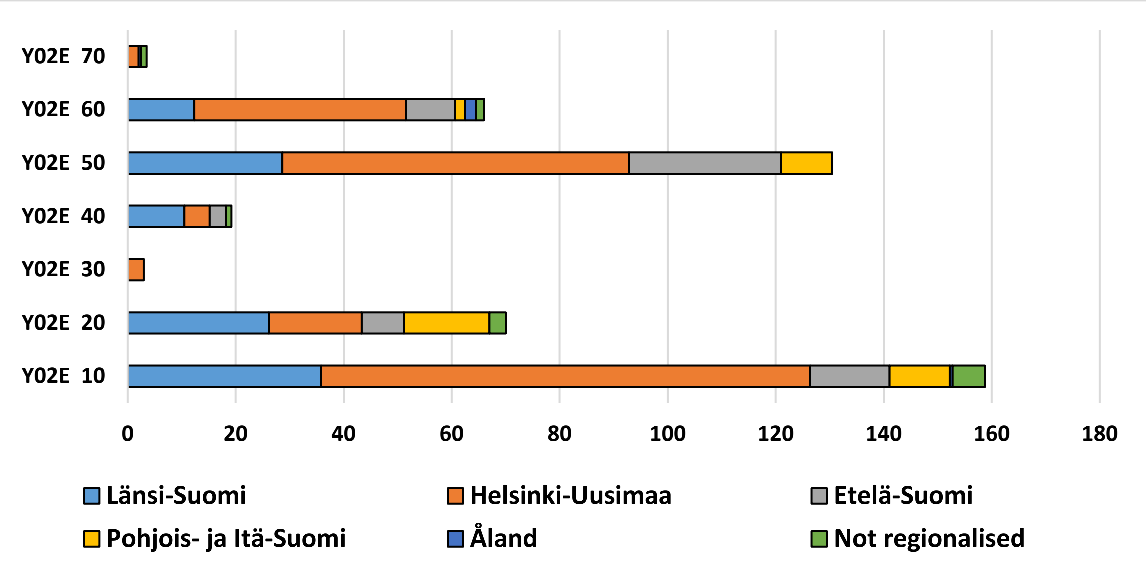

Figure 14 - Distribution of CCM Technologies related to ENERGY (Y02E, and subgroups) across the main regions in Finland

The next category Production or processing of goods (Y02P) has a similar number of patent applications as the Energy category (see Figure 15). When it is broken down into sub-categories, technologies relating to metal processing (Y02P 10) and chemical industry (Y02P 20) are the two categories with the highest level of patenting activities. For patenting activities within technologies relating to metal processing, Länsi-Suomi is more active than Helsinki-Uusimaa. The third largest sub-category is technologies relating to oil refining and petrochemical industry (Y02P 30) with Helsinki-Uusimaa as a far dominant region in patenting.

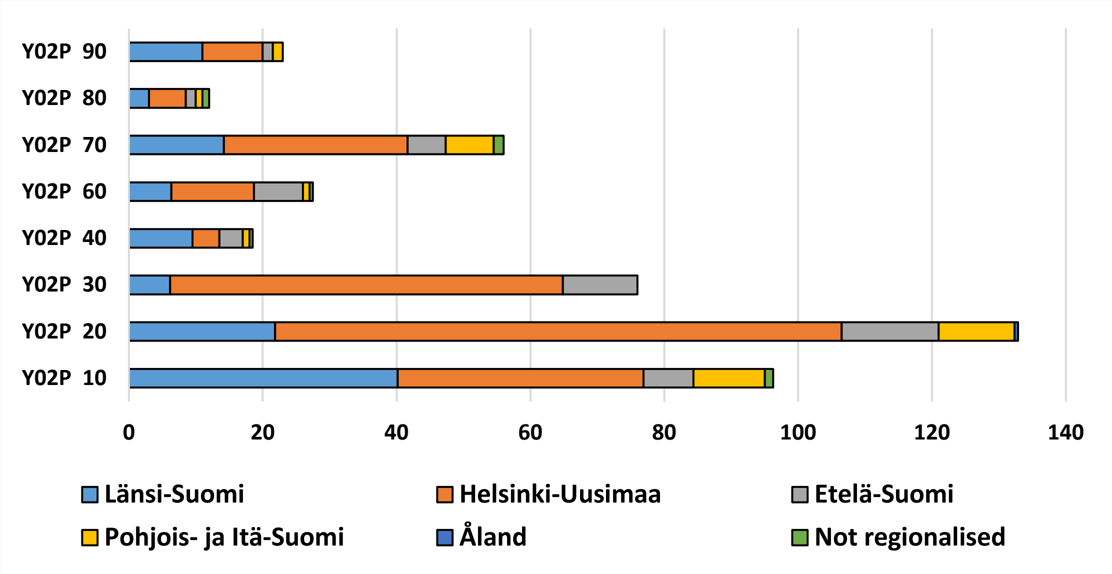

Figure 15 - Distribution of CCM Technologies related to PRODUCTION and PROCESSING of goods (Y02P, and subgroups) across the main regions in Finland

The Transport category (Y02T) includes 255 out of 1658 patent applications in Finland. One dominant sub-category relates to road transport (Y02T 10) and accounts for more than 70% of knowledge production in Transport (see Figure 16). Unlike in other categories, the region Länsi-Suomi leads the patenting activities in this sub-category, taking up more than 65% of the patenting activities. The next sub-category related to maritime or waterways transport (Y02T 70) reveals similar levels of patenting in Helsinki-Uusimaa region and Etelä-Suomi region.

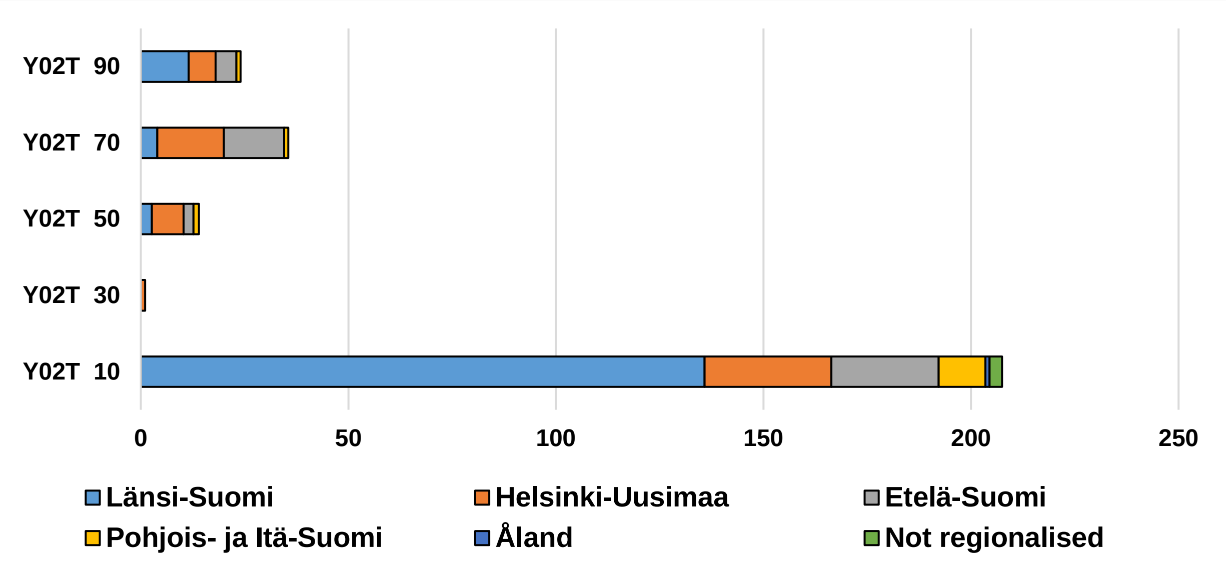

Figure 16 - Distribution of CCM Technologies related to TRANSPORT (Y02T, and subgroups) across the main regions in Finland

With regards to the category Buildings (Y02B), Figure 17 shows that technologies related to energy efficiency in information and communication technologies (Y02B 60) accounts for the majority of the patenting activities (303 out of 420). Helsinki-Uusimaa leads the knowledge generation in this sub-category, followed by Länsi-Suomi. What is notable is the relative importance of Pohjois- ja Itä-Suomi region that has been less active in patenting in other categories of green technologies. In the rest of sub-categories with significantly fewer numbers of patent applications compared to the category Y02B 60, Helsinki-Uusimaa is the most active region of all.

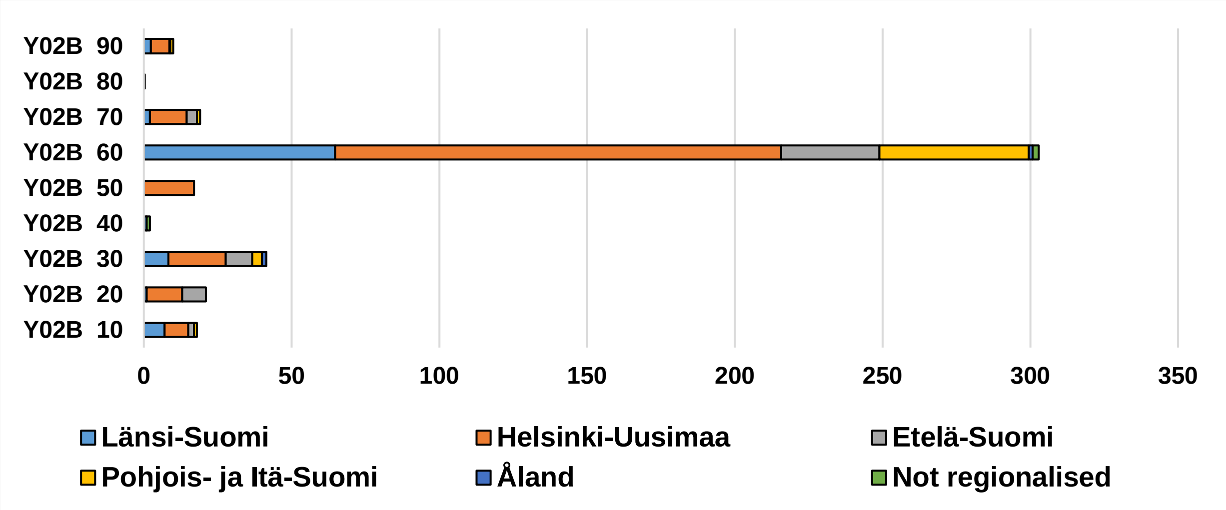

Figure 17 - Distribution of Climate Change Mitigation (CCM) Technologies related to BUILDINGS (Y02B, and subgroups) across the main regions in Finland

Figure 18 shows the HHI index for each region in Finland, indicating the level of diversification on the development of CCM technologies across various categories. All five regions in Finland show a similar level of diversification ranging between 0.21 and 0.34. This range of index suggests that there is a relatively high level of diversification in all regions. Even for the two dominant regions accounting for a large share of CCM technologies, Helsinki-Uusimaa and Länsi-Suomi, the development of technologies has been diversified across different categories.

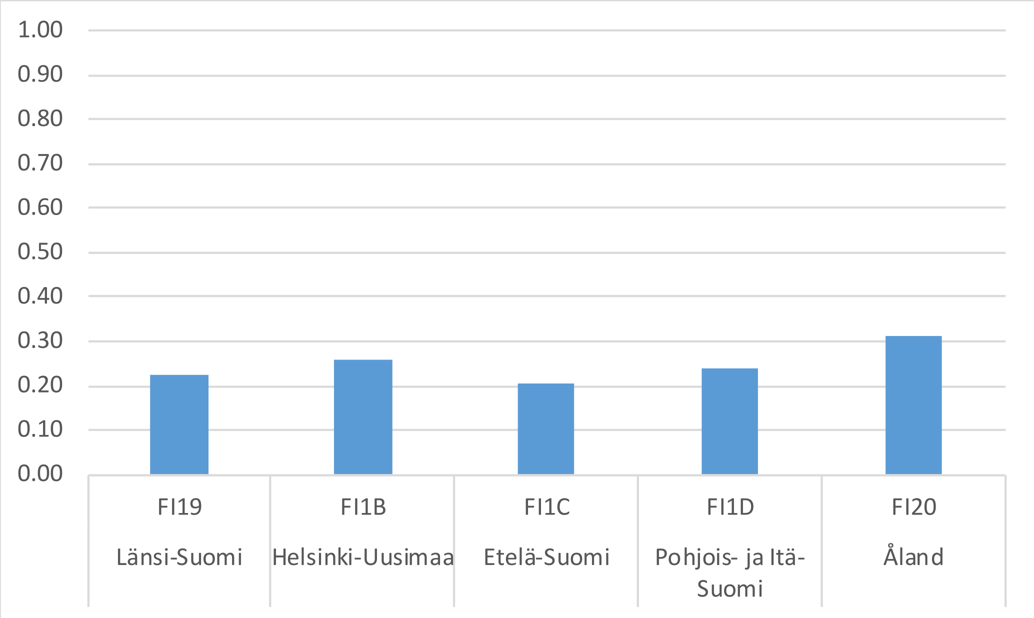

Figure 18 – Herfindahl-Hirschman index – Level of diversification of regions across Finland

Finally, RTA measuring the relative strength of regions in each CCM technology category is presented in Figure 19. Among the four categories that Finland has the highest number of patent applications, Building, Energy, Production or processing of goods, and Transport, Building is where all the regions show relative strength in the category. All regions except for Åland, shows a higher level of patenting in Production or processing of goods than what overall patenting would suggest. The capital region Helsinki-Uusimaa that was leading overall patenting in CCM technologies in Finland shows relative strength in two categories, Buildings and Production or processing of goods. Länsi-Suomi, the second leading region in terms of number of patent application in Finland shows special relative strength in Transport category.

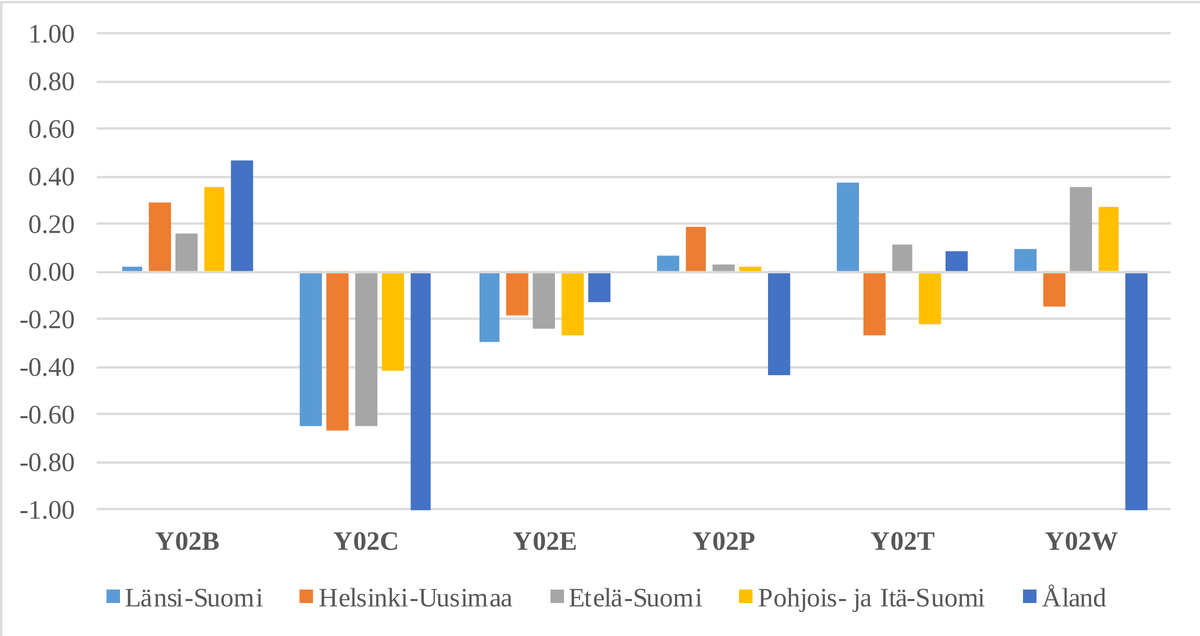

Figure 19 - Revealed Technological Advantages for 6 categories of Climate Change Mitigation technologies across regions in Finland

2.3 Geographical Distribution of Climate Change Mitigation technologies across Norway

Norway is slightly different than its Nordic neighbors in several senses. The most important difference is that Norway only became a full-member of the EPO system in the middle of the period (in 2008). In short, it would have been more expensive for a Norwegian application to go through the EP system. Norwegians would thus have tended to use the domestic office (the Norwegian Industrial Property Organization) much more than equivalent Swedish or Danish firms for most of the period[16]. This section however is limited to the EPO families in line with the other three countries in the interest of comparability.

The Herfindahl-Hirschman index (presented above) is commonly used to relate firm-size to the average market share in an industry: it ranges from 0, where the total market is divided equally among many small entities to 1, in which there is a single monopolistic entity. Figure 20 applies the Herfindahl-Hirschman index to measure the concentration (or diversification) in the 'market' for green patents across seven aggregate regions of Norway.

[16] The effect can be quite substantial: In the presentation of the 15,000 patent applications above that allocate to the SGC categories, inclusion of domestic patent applications for Nordic inventors would have increased the Nordic green patents by a further 6000.

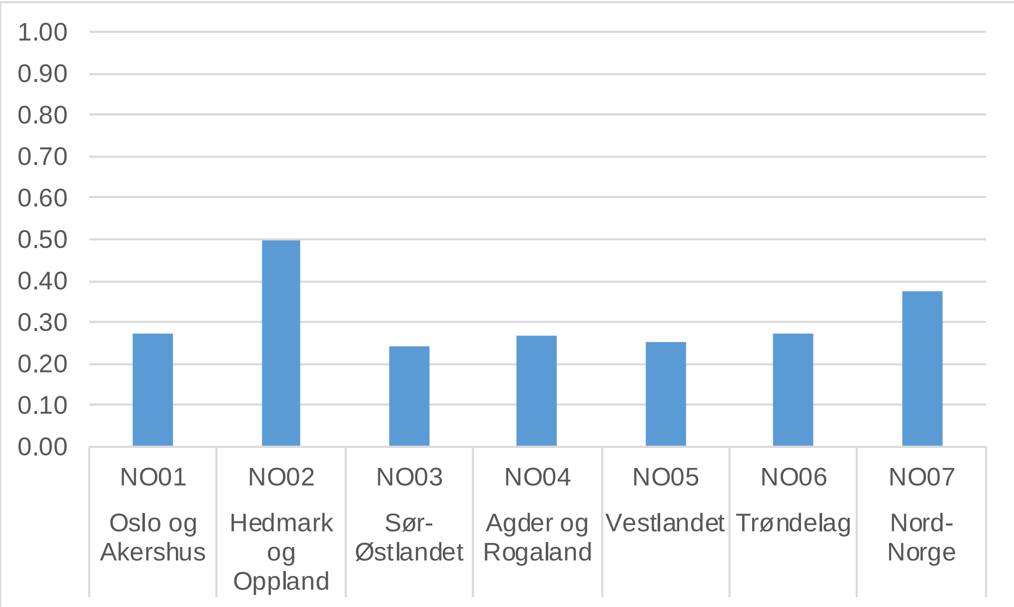

Figure 20 – Herfindahl-Hirschman index – Level of diversification of regions across Norway

The figure indicates a relatively high degree of diversification. Three regions in the Norwegian economy have the same index. The region around Oslo, the region around Trondheim, and the region stretching from Stavanger (Norway's petroleum capital) and southwards are also major population and commercial centres. In addition, two other population centres (Southeastern Norway and the region of Bergen and northward) have broadly similar levels of concentration. Hedmark and Oppland shows the highest relative concentration in green-patenting, followed by Northern Norway. These are more sparsely populated areas, the first associated with agriculture and forestry and the latter with fisheries. To get an idea of how individual regions stack up in relation to the various green technologies, Figure 21 presents green patents in total counts (uppermost bar) followed by the distributions for the six technologies. A first observation is that the regions with the highest levels of concentration (Hedmark & Oppland, and Nord-Norge (Northern Norway)) are also the smallest in terms of total counts.

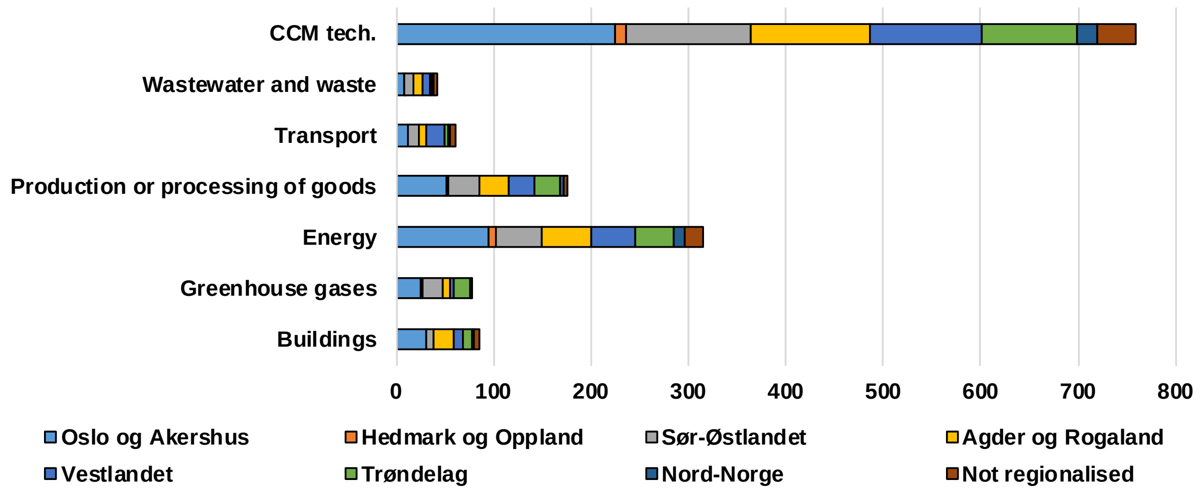

Figure 21 - Distribution of CCM technologies (the six Y02 categories with 4 digits, and total) across regions in Norway

Figure 21 furthermore substantiates another facet of the regional concentration introduced above. It confirms that the five regions that demonstrated similar Herfindahl-Hirschman indices are broadly similar in size. This even distribution is demonstrated in the total and in the technology areas that are clearly largest (Energy and production and processing of goods). There may be other anomolies hidden in the smaller technology areas.

In terms of the total number of patent applications, the largest area by a large margin is the Y02E technology area. This technological family encompasses green 'energy generation, transmission, distribution'. Figure 22 shows that the single largest component of this technology field is energy generation (Y02E 10), which includes hydroelectric (over 95% of energy generation in Norway) as well as wind and solar technologies. We see that the importance of the Oslo region, together with the region around Stavager and Kristiansand (Rogaland and Agder), around Bergen (Vestlandet) and around Trondheim (Trøndelag).

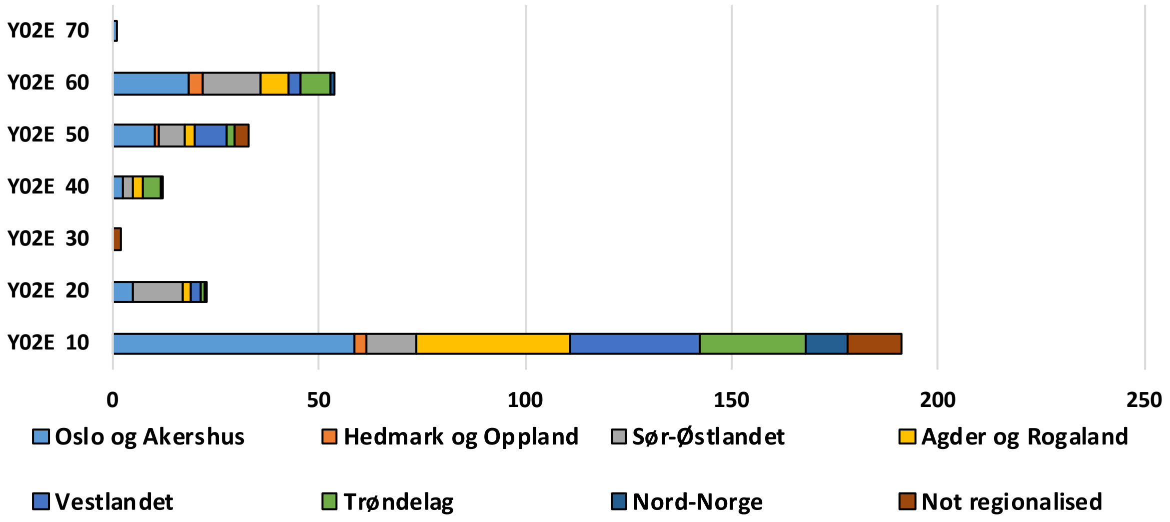

Figure 22 - Distribution of CCM Technologies related to ENERGY (Y02E, and subgroups) across the main regions in Norway

Energy storage and emissions mitigation (Y02E 60) is a distant second in terms of number of patent applications. This subgroup accounts for more than 50 patent applications during the period or only about a third the volume of the energy generation patenting. This area also includes technologies related to fuel cells and hydrogen technologies. Oslo, South Eastern Norway (including Moss) and Trøndelag feature prominently in the patenting activities associated with these technologies. The area of biofuels and fuel from waste (Y02E 50) is the third largest component of green energy patents.

The second largest area of green patenting in terms of numbers of applications (170) involves greening existing production and processing systems (see Figure 23). This diverse technological family spans technologies related to traditional industries such as metal working, petrochemicals as well as agriculture, fisheries and forestry. The scale of patenting in this area is substantially smaller than that of green energy and more evenly spread between subgroups. Moreover, we see that the regional specialization at this level is more varied, reflecting the fact that the underlying industries are located in different regions of the country.

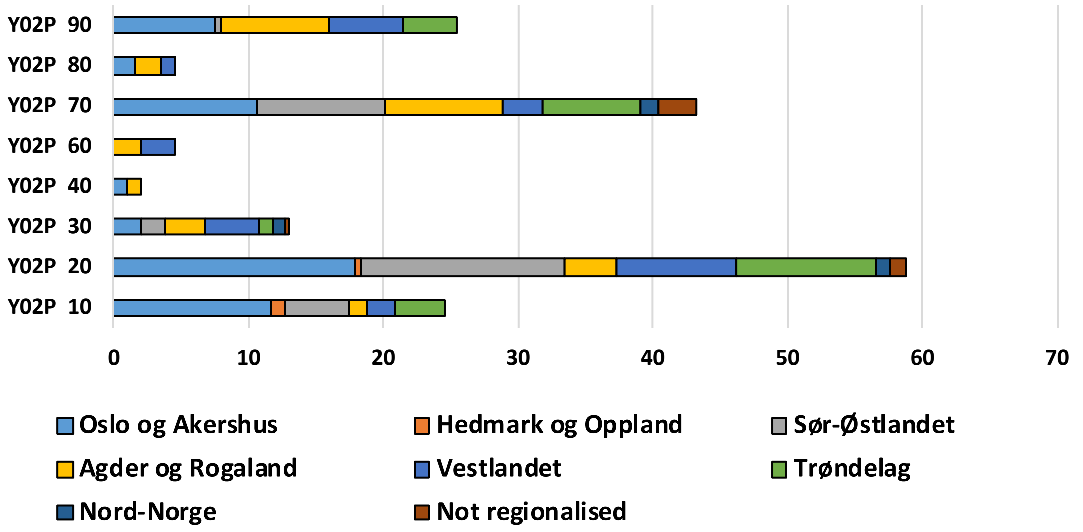

Figure 23 - Distribution of CCM Technologies related to PRODUCTION and PROCESSING of goods (Y02P, and subgroups) across the main regions in Norway

'Technologies relating to the chemical industry' (Y02P 20), which is the largest subgroup in terms of green patenting, can be associated with the neighbouring area relating to petrochemicals (Y02P 30). The south eastern region part of Norway, including both Oslo and Akershus and beyond (Sør-Østlandet) account for the majority of the green patents associated with the chemical industry (Y02P 20). The coastal region stretching from around Bergen (Vestlandet) up to Trondheim (Trøndelag) is also well represented here. The region from Bergen down through Norway's oil capital (Stavanger) down to Kristiansand dominates the relatively small number of petrochemical patents. The second largest category is the diverse family of 'Technologies relating to the production processes of final/consumer goods' (Y02P 70). This technology family is more evenly spread across regions of the country. A third area with over twenty-five applications involves 'Enabling technologies for greenhouse gas emission mitigation' (Y02P 90).

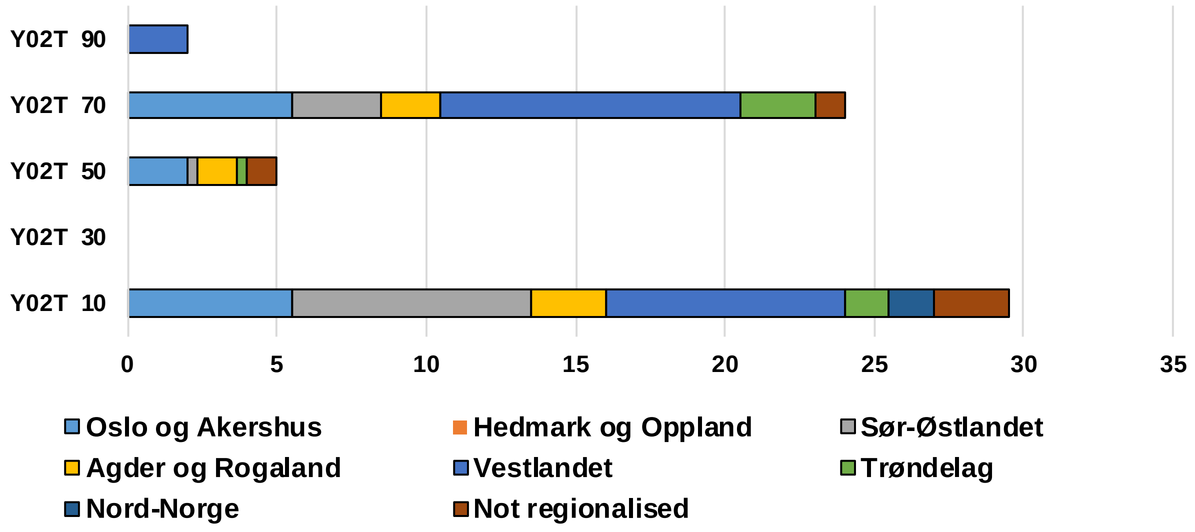

Figure 24 - Distribution of CCM Technologies related to TRANSPORT (Y02T, and subgroups) across the main regions in Norway

Norwegian green patenting in the area of transport systems accounted to just over 50 applications in the period (see Figure 24). Green patenting involving road transport included two main sub-categories, namely (i) improvements to conventional vehicles as well as the development of electric and hybrid vehicles (Y02T 10) and (ii) Maritime transport (Y02T 70) including the reduction of emissions from conventional boats to the development of propellers, etc. The first subgroup may correspond to the reputation that Norway enjoys for improving the uptake of e-mobility into the transport system. The second subgroup can be associated with the longstanding tradition of Norway as a maritime country. A number of shipbuilders, not least those that service the offshore oil industry, have survived competition from cheaper yards in Asia. This has led among other developments to specialization into components markets (e.g. propeller technologies).

Figure 24 demonstrates that western part of the country, where the maritime industry is mainly located, is overrepresented in terms of green technologies in the maritime sector. Vestlandet is also well represented in terms of green road transport patents. However, the south eastern region of the country accounts for about half of the green road transport patents, although here the Oslo region takes a back seat to other parts of this region. The number of patents is however modest.

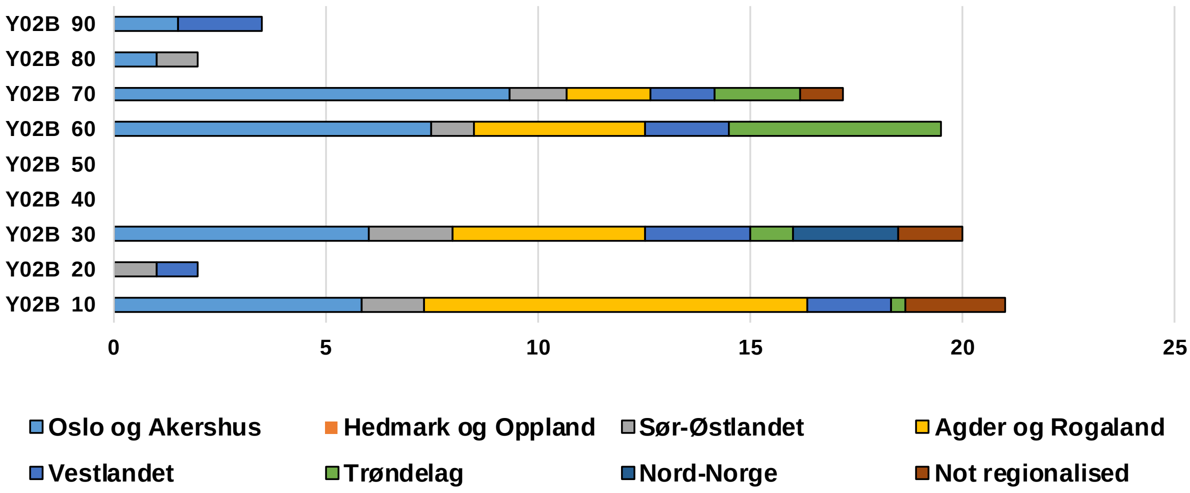

Figure 25 - Distribution of CCM Technologies related to BUILDINGS (Y02B, and subgroups) across the main regions in Norway

Norwegian green patenting in the area of buildings amounted to 80 applications in the period (see Figure 25). Technologies involved in green buildings are divided rather equally to the integration of renewable energy sources in buildings (Y02B 10), energy efficiency in the heating, ventilation or cooling of buildings (Y02B 30), the use of ICT to reduce energy consumption (Y02B 60) and technologies to help reduce energy waste on the part of the user (Y02B 70). The regionalization of these green technologies reveals a leading role of Agder and Rogaland, which also are involved in building and fitting-out oil-rigs. The regions surrounding Oslo together with Trondheim are also notable in this context.

The question that emerges is the degree to which the numbers and distributions are larger than expected or not. The RTA measure introduced above provides some in-country evidence about where green patenting is larger (smaller) than total patenting would suggest. An added advantage of this measure is that it is comparable across regions and countries. However, using it here in this restricted environment can only really reveal a crude indication, not least since it assumes that there is an equal propensity to patent in the different green technologies and not least since it is based on a small number of observations. Figure 26 illustrates that in the Norwegian case there are disproportionately higher (lower) values in areas where the numbers of patents are small

(80 patent applications at most for the whole period). Divvying up this number of patents into seven regions is of limited use in identifying the relative strength of regions in this setting.

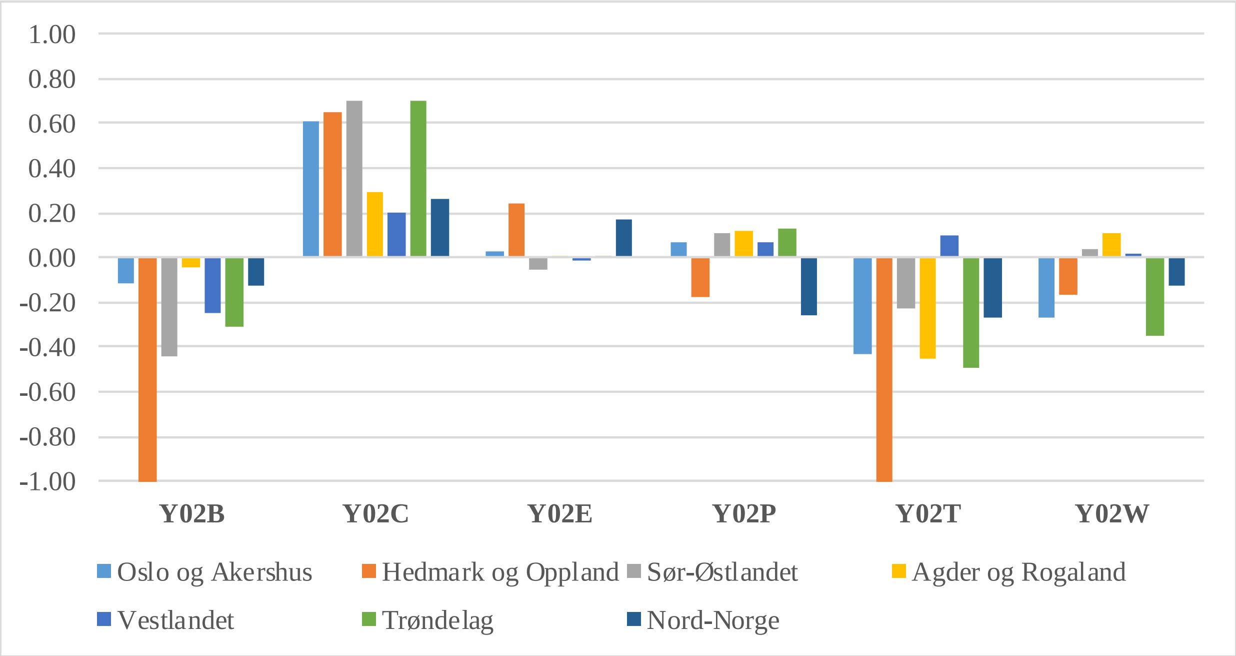

Figure 26 - Revealed Technological Advantages for 6 categories of Climate Change Mitigation technologies across regions in Norway

2.4 Geographical Distribution of Climate Change Mitigation technologies across Sweden

This section analyses CCM technology development in Sweden, focusing on the distribution of these technologies across Swedish regions. Figure 27 presents the overall distribution of CCM technologies (Y02) across Sweden as well as for the different technology classes, such as wastewater treatment or waste management (Y02W), transport (Y02T), production or processing of goods (Y02P), Energy (Y02E) capture, storage, sequestration or disposal of greenhouse gases (Y02C) and buildings (Y02B).

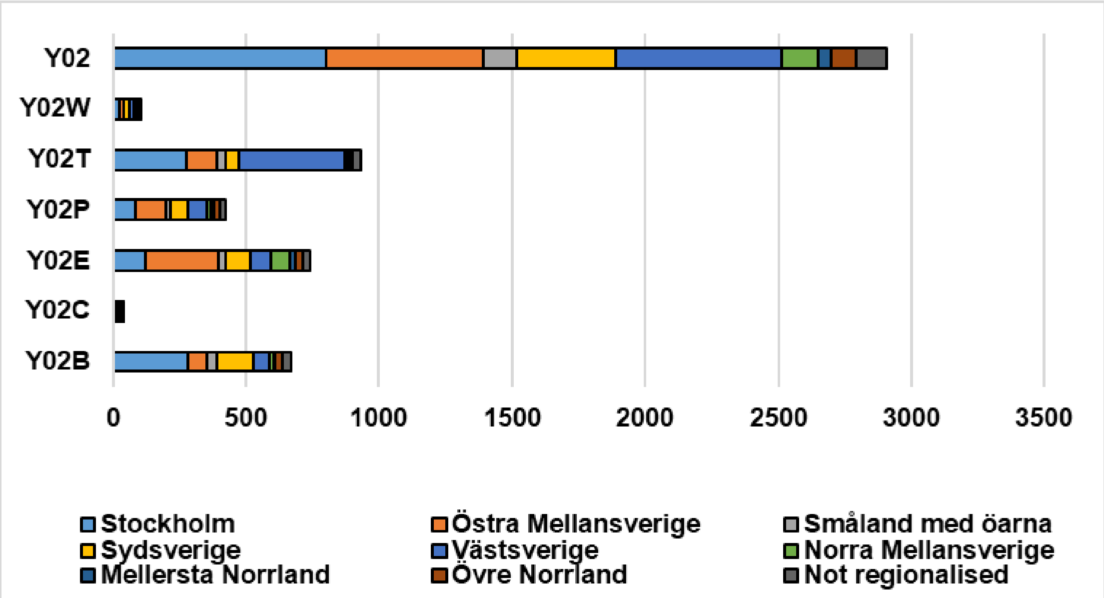

Figure 27 - Distribution of CCM technologies (the six Y02 categories with 4 digits, and total) across regions in Sweden

Figure 27 shows the distribution of CCM technologies and sub-groups across the Swedish regions. Sweden has over 2800 CCM technology patents, which is approximately 40% above the Nordic average, highlighting the high degree of specialization on CCM technologies. The leading regions on the development of CCM technology are Stockholm, Västsverige and Östra Mellansverige followed by Sydsverige. Sweden's stronghold in automotive industry is reflected in the strong position on CCM technologies related to Transport with more than 900 patent families followed by technologies related to Energy (740), Buildings (660) and Production and

Processing of goods (430). The region's leading the CCM technology related to transport are Västsverige and Stockholm, and the region's leading the CCM technology related to Energy are Östra Mellansverige and Stockholm, showing that generally, the leading regions of general CCM technologies are also the ones leading the CCM technology related to Energy and Transport. Two technology areas are less represented in Sweden, namely Wastewater treatment and waste management as well as capture, storage, sequestration or disposal of greenhouse gases, which is a general trend for all the Nordic countries.

Figure 28 shows the regional distribution of Swedish CCM technology related to Energy, on subgroups covering: renewable energy generation (Y02E 10), Combustion technologies with mitigation potential (Y02E 20), nuclear energy (Y02E 30), efficient electrical power generation transmission or distribution (Y02E 40), energy generation from fuels of non-fossil origin (Y02E 50), enabling technologies (Y02E 60) and other energy conversion or management systems reducing GHG emissions (Y02E 70).

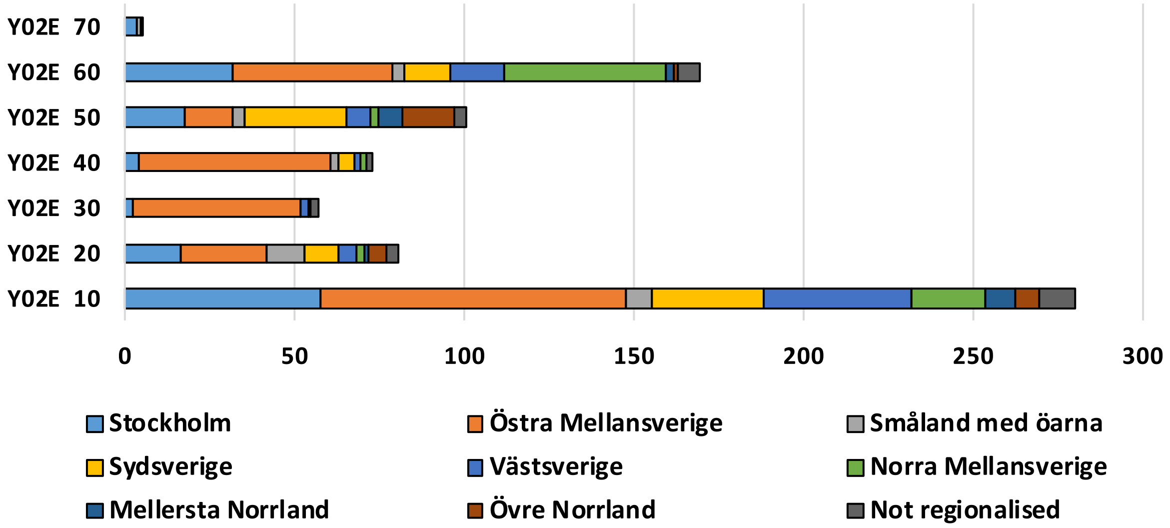

Figure 28 - Distribution of CCM Technologies related to ENERGY (Y02E, and subgroups) across the main regions in Sweden

The figure shows that within the Energy area, renewable energy generation (Y02E 10) and enabling technologies (Y02E 60), which are technologies with potential or indirect contribution to emission mitigation, are the subgroups with most patent families. The leading regions on the development of renewable energy are Östra Mellansverige (90), Stockholm (58) and Västsverige (44). The leading region of enabling technologies are both Östra Mellansverige and Norre Mellansverige (45 patent families each), differently from the distribution of CMM technology related to renewable energy, Norra Mellansverige does not perform as a leading region on CCM technology in general, underlining a potential specialization of the region in enabling technologies.

The following figure (Figure 29) shows more in depth the regional distribution of Swedish CCM technologies related to production and processing of goods divided per technologies related to metal processing (Y02P 10), technologies relating to chemical industry (Y02P 20), technologies relating to oil refining and petrochemical industry (Y02P 30), technologies relating to the processing of minerals (Y02P 40), technologies relating to agriculture, livestock or agroalimentary industries (Y02P 60), technologies in the production process for final industrial or consumer products (Y02P 70), climate change mitigation technologies for sector-wide applications (Y02P 80), enabling technologies (Y02P 90).

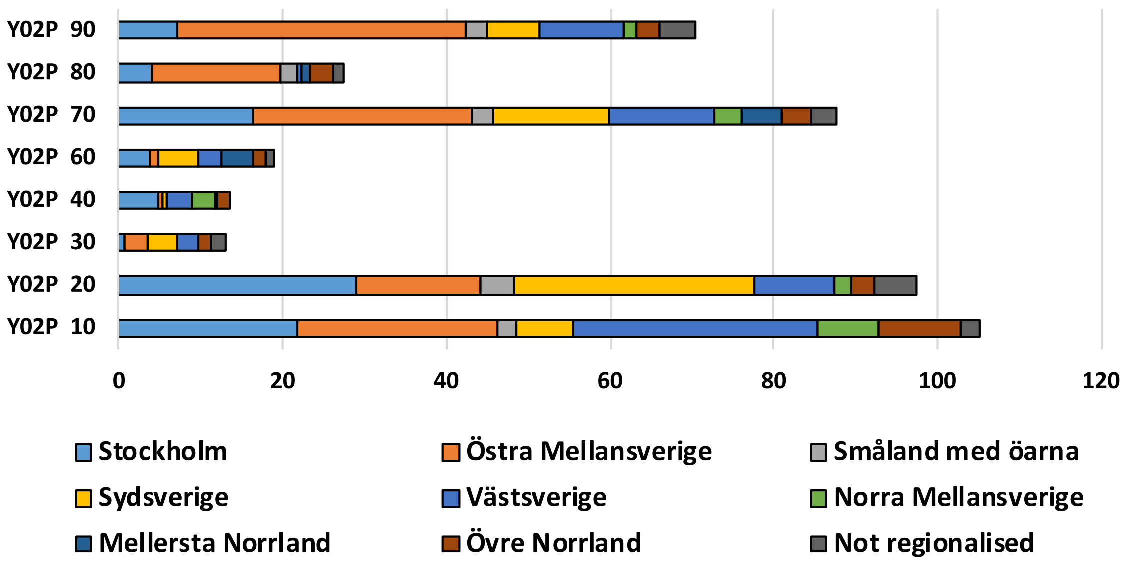

Figure 29 - Distribution of CCM Technologies related to PRODUCTION and PROCESSING of goods (Y02P, and subgroups) across the main regions in Sweden

Within the production and processing of goods technologies, Sweden presents more CCM technologies related to metal processing, followed by CCM technologies related to chemical industry and production process for final industry or consumer products. The leading regions on the development of CCM technologies related to metal processing (Y02P 10) are Mellersta Norrland, Östra Mellansverige and Stockholm. Similarly, the leading region on CCM technologies related to chemical industry (Y02P 20) is Sydsverige, Stockholm and Östra Mellansverige. Sydsverige is a moderate contributor to CCM technologies in general and its dominating role in Y02P 20 indicates a relative specialization in CCM technologies related to chemical industry.

Figure 30 shows the regional distribution of Swedish CCM technologies related to transport and divided by subgroups, including road transport (Y02T 10), rail transport (Y02T 30), air transport (Y02T 50), maritime or waterways transport (Y02T 70) and enabling technologies in transport (Y02T 90). Sweden presents a strong focus on CCM technologies related to road transport (820 out of 1008 patent families, equal to 81%). The development of these technologies are concentrated on Västsverige (351 CCM technologies) and Stockholm (264 CCM technologies). In sum, the figure shows the high concentration within transport technology on the development of CCM related to road transport.

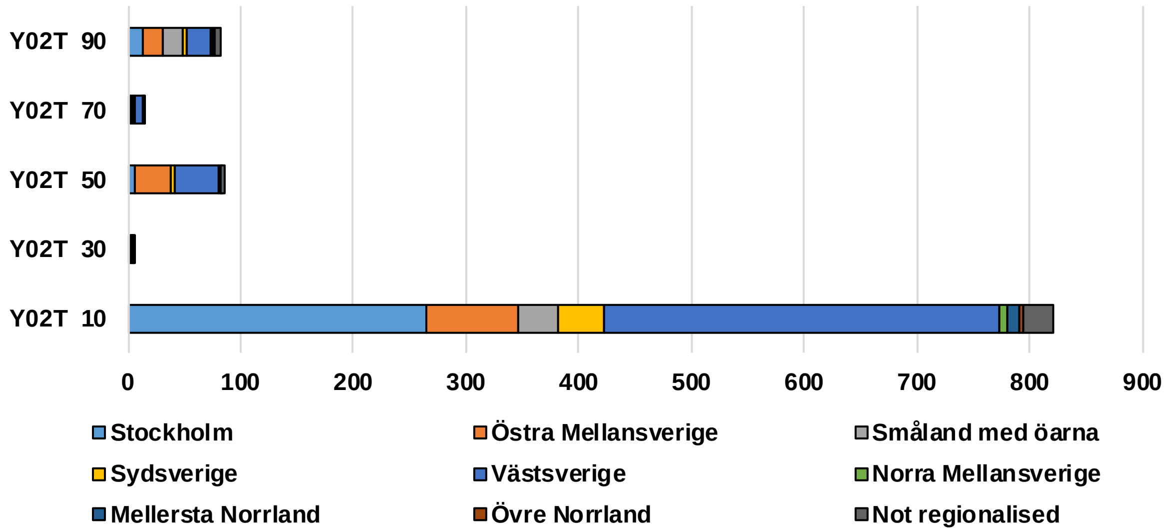

Figure 30 - Distribution of CCM Technologies related to TRANSPORT (Y02T, and subgroups) across the main regions in Sweden

Figure 31 shows the regional distribution of CCM technologies related to buildings split between sub-groups: integration of renewable energy sources (Y02B 10), energy efficiency in lightning (Y02B 20), energy efficiency in heating, ventilation or air conditioning (Y02B 30), energy efficiency in home appliances (Y02B 40), energy efficiency in elevators, escalators and moving walkways (Y02B 50), energy efficiency in information and communication technologies (Y02B 60), energy efficiency in end-user side (Y02B 70), architectural or constructional elements improving the thermal performance of buildings (Y02B 80) and enabling technologies in buildings (Y02B 90). Sweden's CCM technologies in buildings are highly specialized on energy efficiency related to information and communication technologies (67 %). The leading regions of these type of technologies are Stockholm (210 patent families) and Sydsverige (118 patent families).

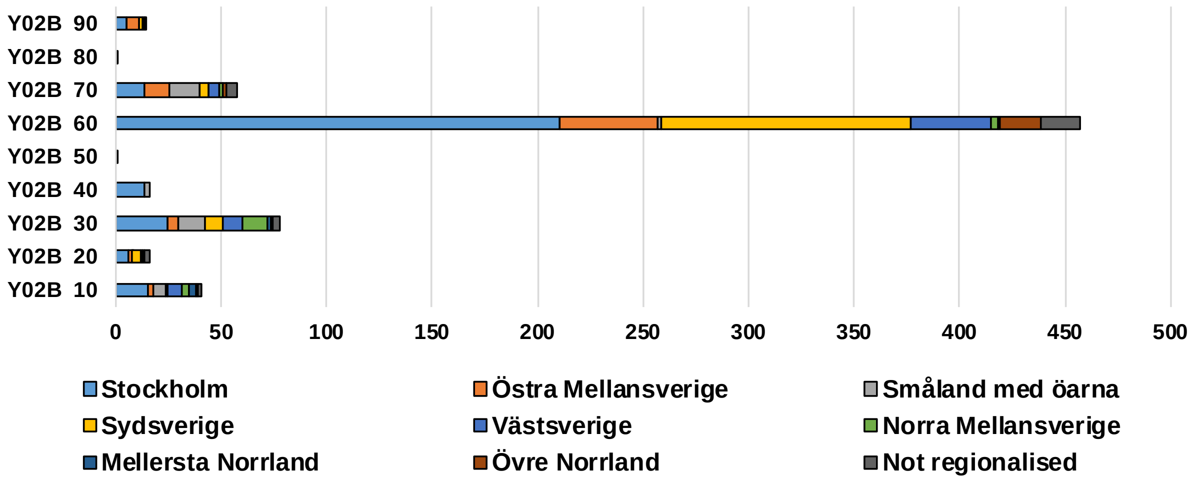

Figure 31 - Distribution of CCM Technologies related to BUILDINGS (Y02B, and subgroups) across the main regions in Sweden

Figure 32 shows the level of diversification on CCM across Sweden. In general, the HHI index in the figure shows the relative level of diversification on the development of CCM technologies across the different sub-groups. The range varies from 0 (high level of diversification) in which the region presents the development of CCM technologies from several CCM sub-groups and 1 (high level of concentration) in which the region may concentrate its activities in one or few sub-groups.

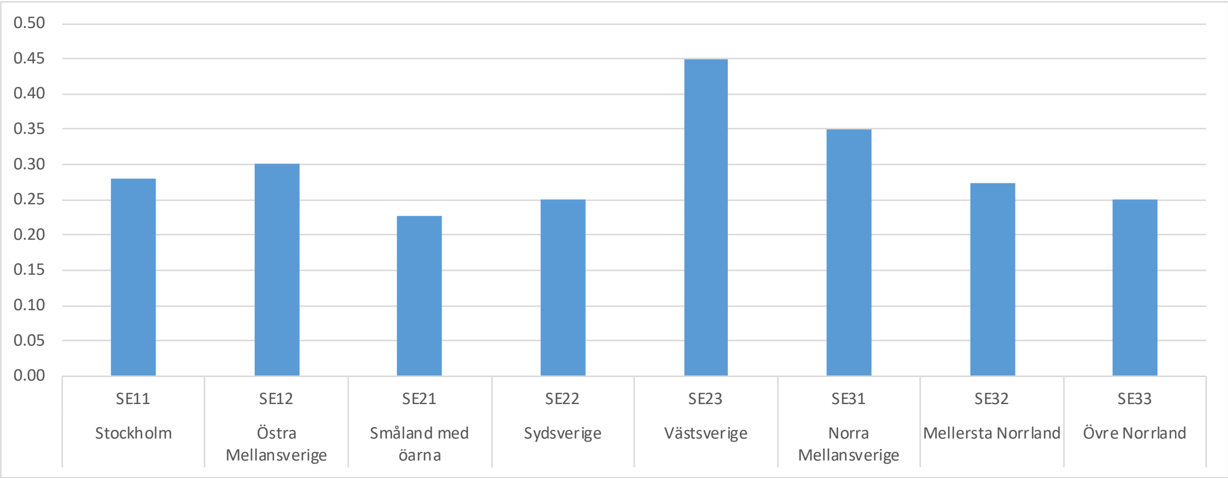

Figure 32- Herfindahl-Hirschman index – Level of diversification of regions across Sweden

The range of relative diversification across Sweden varies from 0.23 to 0.45. Västsverige has the highest level of concentration (0.45) mirroring its strength and strong focus on CCM related to transport. Most of the remaining regions are more diversified which means they are patenting within several CCM sub-groups.

Figure 33 shows the RTA of CCM technologies across Sweden across the CCM technology sub-groups (wastewater treatment or waste management (Y02W), transport (Y02T), production or processing of goods (Y02P), Energy (Y02E) capture, storage, sequestration or disposal of greenhouse gases (Y02C) and buildings (Y02B)).

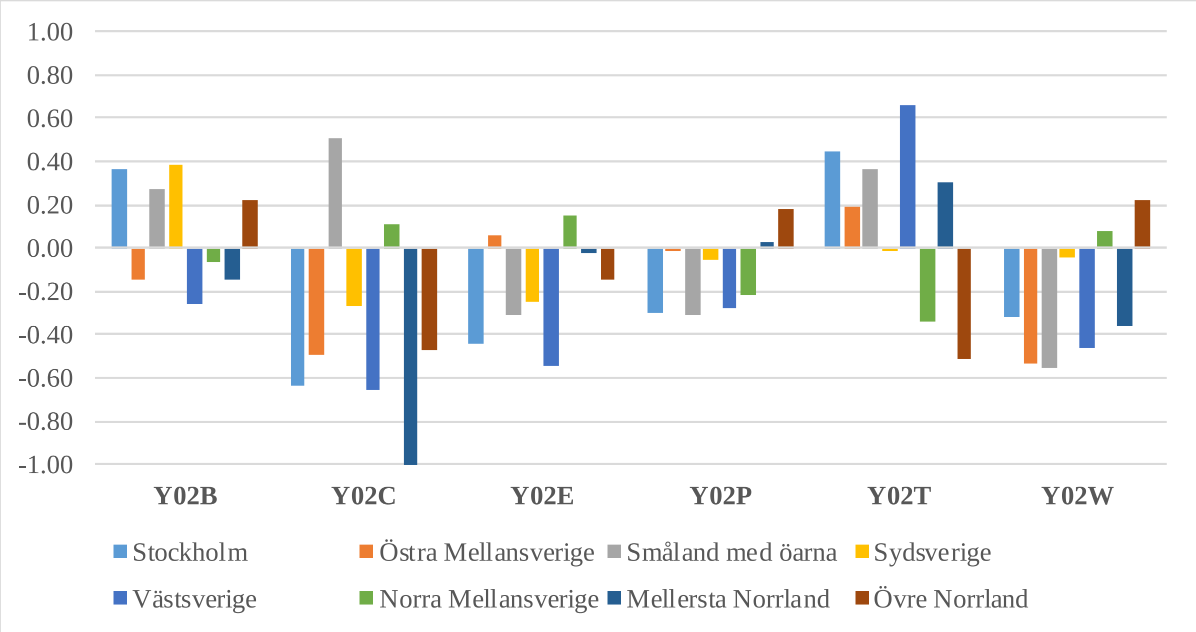

Figure 33 - Revealed Technological Advantages for 6 categories of Climate Change Mitigation technologies across regions in Sweden

Figure 33 shows that the CCM technologies related to Transport has more regions with positive RTA than the Swedish average, revealing the strong focus on the automotive industry in Sweden.

Overall, these results shows that despite some differences on the leadership of CCM technologies at the sub-group levels across Swedish regions, the leading regions of Stockholm, Västsverige and Östra Mellansverige presents a strong focus on the development of CCM technologies in general and within different sub-groups. At the country-level Sweden, presents a strong focus on CCM technologies related to transport.

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Appendix A

Appendix A shows the full list of papers reviewed to assess the use of various patent classification systems across 45 selected papers:

Paper	OECD ENV-TECH	WIPO Green Inventory	EPO Y-tags	Fraunhover ISI	Keyword search	Other	Remarks
(Amore & Bennedsen, 2016)						X	Uses the classification created by Carrión-Flores & Innes (2010)
(Albino et al., 2014)		X					
(Ardito et al., 2016)		X					
(Barbieri, 2015)			X				
(Bel & Joseph, 2018)			X				
(Bermúdez-Edo et al., 2017)			X				
(Budde et al., 2015)	X						
(Carrión-Flores & Innes, 2010)						X	Develop their own classification based on USPTO patent codes
(Cecere & Corrocher, 2016)		X					
(Cecere et al., 2014)		X				X	Combines the OECD list of ICT technologies with the WIPO Green Inventory
(Corrocher & Solito, 2017)		X					

(Costantini, Crespi, & Curci, 2015)		X			X	X	Developed their own method based on algorithms and keyword search and compared with the WIPO Green Inventory (BioPat) (See also Costantini et al. (2013))
(Curci & Mongeau Ospina, 2016)						X	Uses the Biopat developed by Costantini et al. (2013)
(Dechezleprêtre, Glachant, Haščič, Johnstone, & Meniere, 2011)						X	Develop their own list of IPC codes related with green patents
(Durán-Romero & Urraca-Ruiz, 2015)		X					
(Faria and Andersen, 2017a)	X	X					
(Faria and Andersen, 2017b)	X	X					
(Fabrizi, Guarini, & Meliciani, 2018)	X						
(Fujii & Managi, 2016)		X					
(Gagliardi, Marin, & Miriello, 2016)	X						
(Ghisetti & Quatraro, 2013)		X					Discuss the differences among the different green patent classifications and chose the WIPO's Green Inventory based

							on the fact that their analysis has a wide scope "which encompasses many kinds of green technologies"
(Ghisetti & Quatraro, 2017)	X	X					
(Karvonen, Kapoor, Uusitalo, & Ojanen, 2016)		X			X		Selects patents based on the Green Inventory codes then narrow the results using relevant keywords
(Kessler & Sperling, 2016)		X	X			X	Compares three methodologies: the Green Inventory, the Y-tags and their own method using natural language processing and machine learning algorithms to identify the green patents
(Kılkış, 2016)		X			X		Uses the keywords on the WIPO list (instead of IPC codes) to conduct the search
(Johnstone, Haščič, & Popp, 2010)						X	Develop their own list of green IPC codes for energy-related CCMT
(Lei et al., 2013)		X			X		Uses the WIPO Green Inventory and filters the results according to keywords

(Leoncini, Marzucchi, Montresor, Rentocchini, & Rizzo, 2017)	X	X					
(Leydesdorff, Alkemade, Heimeriks, & Hoekstra, 2015)			X				
(Li, Huang, Ren, Chen, & Ning, 2016)					X		
(Li et al., 2017)					X		
(Li, Zhao, Zhang, Chen, & Cao, 2018)					X		
(Marin & Lotti, 2017)	X	X					Defines eco-innovation as those patents with at least one IPC code belonging to the groups selected by the OECD or by the WIPO
(Marin & Palma, 2017)			X				
(Míguez et al., 2018)			X				
(Montobbio & Solito, 2018)		X					
(Nesta, Vona, & Nicolli, 2014)						X	Follow the list provided by Johnstone et al. (2010)
(Messeni Petruzzelli, Maria Dangelico, Rotolo, & Albino, 2011)					X		
(Radu & Francoeur, 2017)		X					

(Ranaei, Karvonen, Suominen, & Kässi, 2016)		X				X	The study used the IPC codes from WIPO Green Inventory combined with additional IPC classes based on expert opinion, and used a text-processing tool to classify and filter irrelevant patents from the sample
(Shapira, Gök, Klochikhin, & Sensier, 2014)					X	X	Uses a list of green companies in UK with a list of keywords provided by the Derwent Manual Codes for Green Technology
(Walz, Pfaff, Marscheider-Weidemann, & Glöser-Chahoud, 2017)				X			
(Weina, Gilli, Mazzanti, & Nicolli, 2016)	X						
(Wurlod & Noailly, 2018)						X	Follow the list provided by Dechezleprete et al. (2011)
(Zheng & Kammen, 2014)		X					

Appendix B

Figure 34 to Figure 37 compare the distribution of patents filed to the EPO and national offices for the four Nordic countries (Denmark, Finland, Norway and Sweden) across the six technology groups.

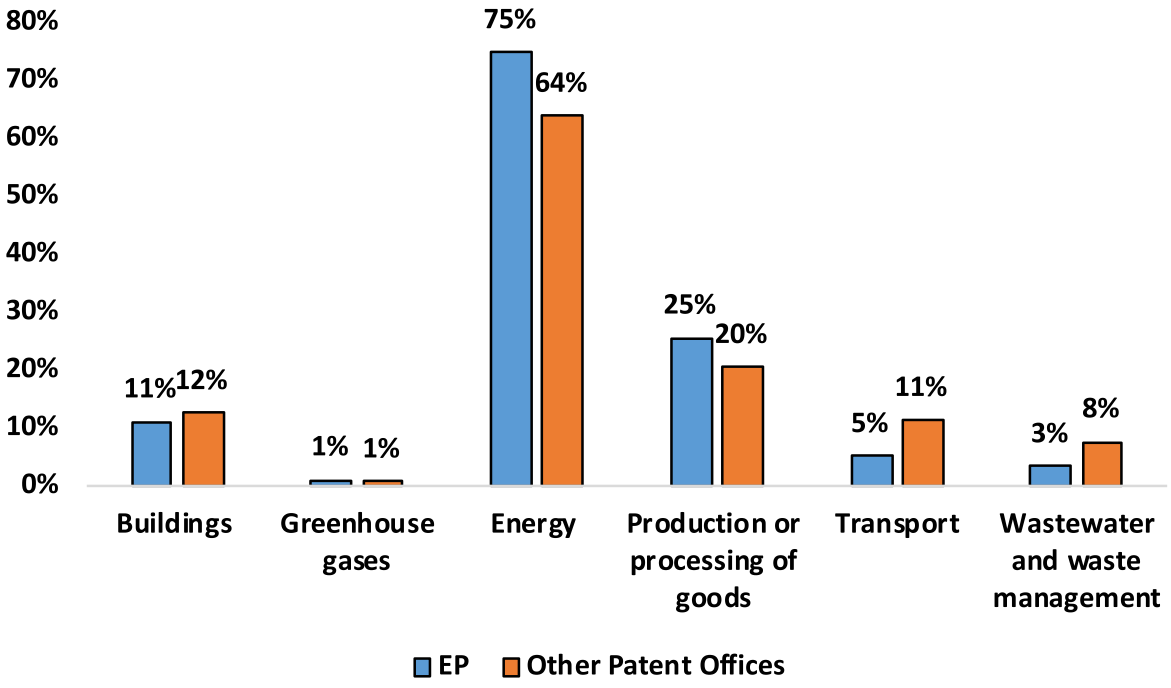

Figure 34- Distribution of patents among the six technological areas for EPO and other Patent offices – Denmark

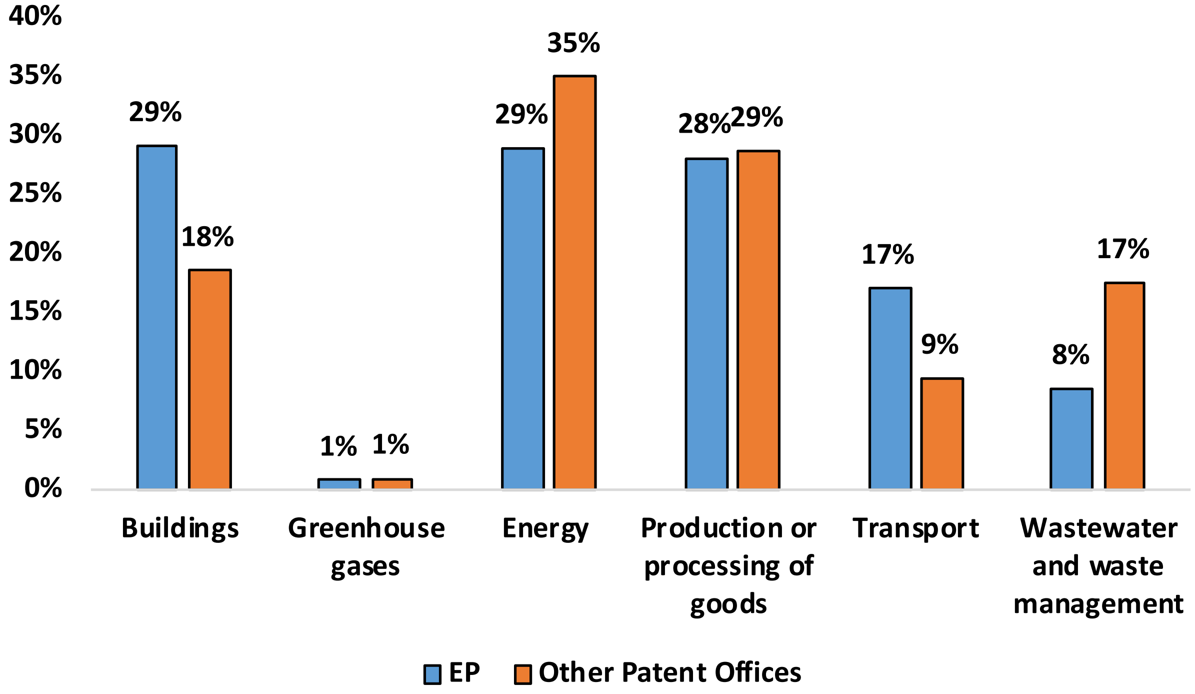

Figure 35- Distribution of patents among the six technological areas for EPO and other Patent offices – Finland

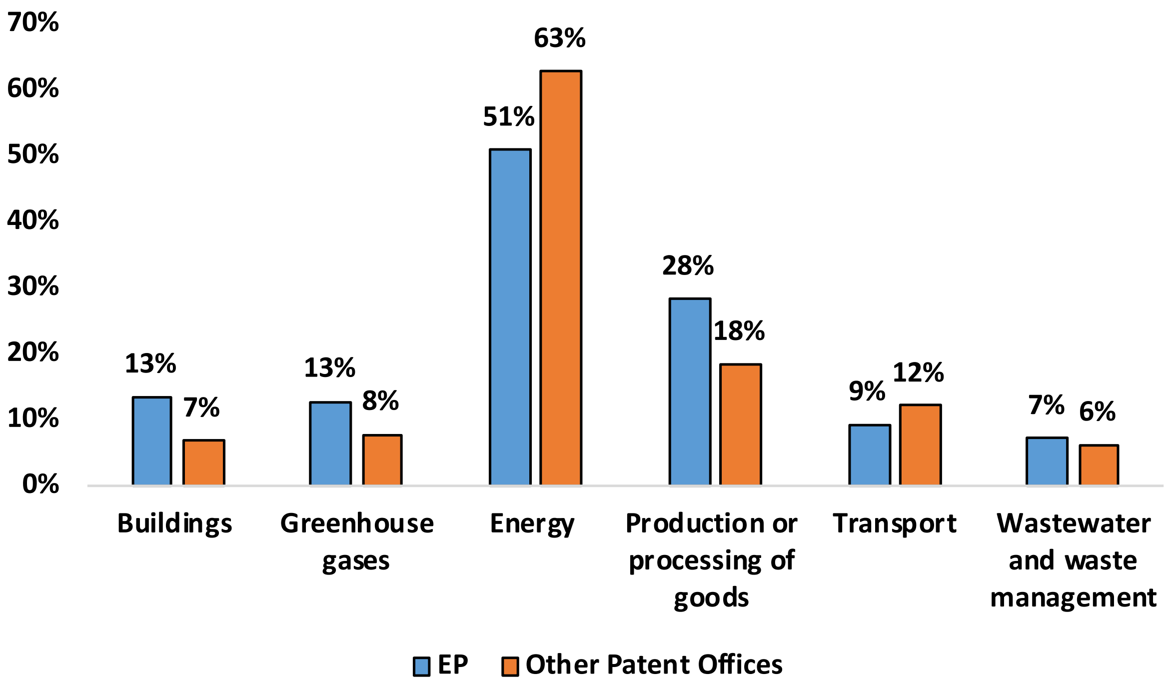

Figure 36- Distribution of patents among the six technological areas for EPO and other Patent offices – Norway

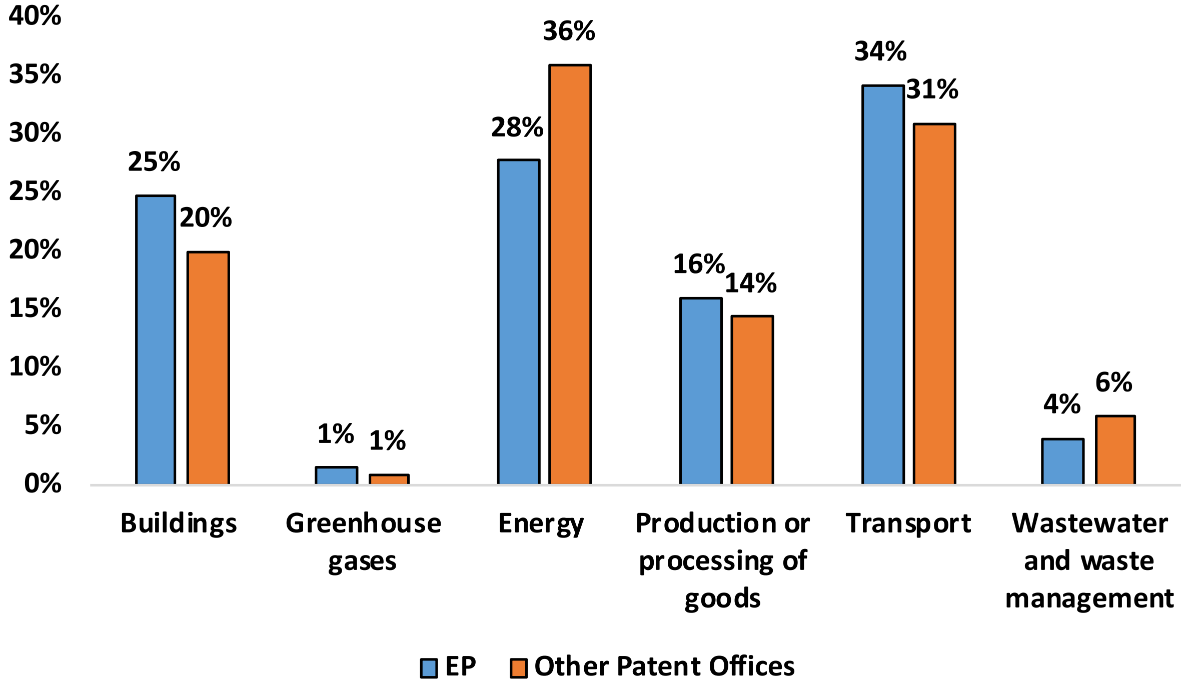

Figure 37 - Distribution of patents among the six technological areas for EPO and other Patent offices – Sweden

Appendix C

Sumplementary tables - Geographical Distribution of Climate Change Mitigation technologies across the Nordic countries.

Table A 1- Distribution of Climate Change Mitigation (CCM) technologies (the six Y02 categories with 4 digits, and total)

	NUTS-2 Region	Code	Y02B	Y02C	Y02E	Y02P	Y02T	Y02W	Y02
Denmark	**DK_not regionalised**	**DK**	8	0	43	15	2	3	70
	Hovedstaden	**DK01**	58	9	277	183	61	26	614
	Sjælland	**DK02**	16	0	60	47	7	15	144
	Syddanmark	**DK03**	60	15	499	168	16	7	765
	Midtjylland	**DK04**	94	1	947	198	18	25	1283
	Nordjylland	**DK05**	38	0	82	34	10	7	170
	Not regionalised	**DKXX**	3	0	20	4	3	1	31
	Not classified	**DKZZ**	1	0	9	4	2	0	17
Finland	**FI_not regionalised**	**FI**	2	0	6	3	2	0	12
	Länsi-Suomi	**FI19**	82	3	106	111	140	38	480
	Helsinki-Uusimaa	**FI1B**	221	5	210	217	57	36	747
	Etelä-Suomi	**FI1C**	54	2	60	51	40	33	240
	Pohjois- ja Itä-Suomi	**FI1D**	56	2	38	34	14	19	162
	Åland	**FI20**	2	0	2	1	1	0	5
	Not regionalised	**FIXX**	1	0	4	1	1	0	7
	Not classified	**FIZZ**	0	0	1	1	0	0	2
Norway	**NO_not regionalised**	**NO**	4	1	15	2	4	3	29
	Oslo og Akershus	**NO01**	28	26	91	48	11	8	212
	Hedmark og Oppland	**NO02**	0	2	7	2	0	1	11
	Sør-Østlandet	**NO03**	8	21	46	31	10	9	126
	Agder og Rogaland	**NO04**	18	6	49	30	6	10	117
	Vestlandet	**NO05**	11	5	44	26	18	8	111
	Trøndelag	**NO06**	8	16	40	25	4	3	97
	Nord-Norge	**NO07**	3	1	11	2	2	1	19
	Not regionalised	**NOXX**	1	1	3	2	1	1	7
	Not classified	**NOZZ**	0	0	1	1	0	1	2
Sweden	**SE_not regionalised**	**SE**	23	0	8	8	14	2	54
	Stockholm	**SE11**	283	5	126	87	275	27	803
	Östra Mellansverige	**SE12**	72	6	271	114	115	12	590

	Småland med öarna	**SE21**	36	12	27	13	35	2	125
	Sydsverige	**SE22**	137	6	91	65	47	22	368
	Västsverige	**SE23**	60	4	75	71	402	15	626
	Norra Mellansverige	**SE31**	19	5	74	17	9	10	134
	Mellersta Norrland	**SE32**	6	0	19	10	12	2	49
	Övre Norrland	**SE33**	24	1	29	27	4	10	93
	Not regionalised	**SEXX**	2	0	10	6	16	3	36
	Not classified	**SEZZ**	6	0	8	3	1	2	19

Table A 2 - Distribution of Climate Change Mitigation (CCM) Technologies related to ENERGY (Y02E, and subgroups) across Nordic countries

	NUTS	**CCM related to ENERGY**	**RENEWABLE ENERGY GENERATION**	**COMBUSTION TECHNOLOGIES WITH MITIGATION POTENTIAL (e.g. using fossil fuels, biomass, waste, etc.)**	**NUCLEAR ENERGY**	**TECHNOLOGIES FOR AN EFFICIENT ELECTRICAL POWER GENERATION, TRANSMISSION OR DISTRIBUTION**	**ENERGY GENERATION FROM FUELS OF NON-FOSSIL ORIGIN**	**ENABLING TECHNOLOGIES (Technologies with potential or indirect contribution to emissions mitigation)**	**OTHER ENERGY CONVERSION OR MANAGEMENT SYSTEMS REDUCING GHG EMISSIONS**
		Y02E	**Y02E 10**	**Y02E 20**	**Y02E 30**	**Y02E 40**	**Y02E 50**	**Y02E 60**	**Y02E 70**
WORLD		36656	19249	2471	1289	1006	3620	9120	213
NORDIC Countries (DK, FI, NO, SE) CNTRY		3406	2230	216	60	169	449	405	22
Denmark	**DK**	1949	1608	43	0	67	187	120	12
Finland	**FI**	435	162	70	3	20	131	69	4
Norway	**NO**	315	195	24	2	13	34	55	1
Sweden	**SE**	763	290	82	57	76	105	176	6

Table A 3 - Distribution of Climate Change Mitigation (CCM) Technologies related to ENERGY (Y02E, and subgroups)

	NUTS-2 Region	Code	Y02E 10	Y02E 20	Y02E 30	Y02E 40	Y02E 50	Y02E 60	Y02E 70	Y02E
Denmark	DK_not regionalised	DK	40	2	0	0	2	1	0	45
	Hovedstaden	DK01	96	14	0	9	118	47	1	285
	Sjælland	DK02	35	3	0	1	8	15	1	62
	Syddanmark	DK03	437	17	0	10	22	33	2	521
	Midtjylland	DK04	907	5	0	42	21	17	6	997
	Nordjylland	DK05	73	2	0	3	5	4	2	88
	Not regionalised	DKXX	15	1	0	2	3	1	0	21
	Not classified	DKZZ	1	0	0	0	8	0	0	9
Finland	FI_not regionalised	FI	5	1	0	0	0	1	1	8
	Länsi-Suomi	FI19	36	26	0	11	29	12	0	114
	Helsinki-Uusimaa	FI1B	91	17	3	5	64	39	2	221
	Etelä-Suomi	FI1C	15	8	0	3	28	9	0	63
	Pohjois- ja Itä-Suomi	FI1D	11	16	0	0	10	2	0	38
	Åland	FI20	1	0	0	0	0	2	1	3
	Not regionalised	FIXX	0	2	0	1	0	1	0	4
	Not classified	FIZZ	1	0	0	0	0	0	0	1
Norway	NO_not regionalised	NO	11	0	2	0	3	0	0	16
	Oslo og Akershus	NO01	59	5	0	2	10	18	1	95
	Hedmark og Oppland	NO02	3	0	0	0	1	4	0	7
	Sør-Østlandet	NO03	12	12	0	3	6	14	0	47
	Agder og Rogaland	NO04	37	2	0	2	3	7	0	51
	Vestlandet	NO05	32	3	0	0	8	3	0	45
	Trøndelag	NO06	25	1	0	4	2	7	0	40
	Nord-Norge	NO07	10	0	0	0	0	1	0	11
	Not regionalised	NOXX	1	1	0	1	0	0	0	3
	Not classified	NOZZ	1	0	0	0	0	0	0	1
Sweden	SE_not regionalised	SE	3	0	1	1	0	5	1	11
	Stockholm	SE11	58	16	2	4	17	32	4	133
	Östra Mellansverige	SE12	90	26	49	56	15	47	0	283
	Småland med öarna	SE21	8	11	0	3	4	4	1	29
	Sydsverige	SE22	33	10	0	5	30	13	0	91
	Västsverige	SE23	44	5	2	2	8	16	0	77
	Norra Mellansverige	SE31	22	3	1	2	2	47	0	76

Mellersta Norrland	**SE32**	9	1	0	0	7	3	0	19
Övre Norrland	**SE33**	7	6	0	0	15	1	0	29
Not regionalised	**SEXX**	3	3	1	1	2	1	0	10
Not classified	**SEZZ**	5	1	0	1	2	1	0	9

Table A 4 - Distribution of Climate Change Mitigation (CCM) Technologies in the PRODUCTION and PROCESSING of goods (Y02P, and subgroups) across Nordic countries

		CLIMATE CHANGE MITIGATION TECHNOLOGIES IN THE PRODUCTION OR PROCESSING OF GOODS	TECHNOLOGIES RELATED TO METAL PROCESSING	TECHNOLOGIES RELATING TO CHEMICAL INDUSTRY	TECHNOLOGIES RELATING TO OIL REFINING AND PETROCHEMICAL INDUSTRY	TECHNOLOGIES RELATING TO THE PROCESSING OF MINERALS	TECHNOLOGIES RELATING TO AGRICULTURE, LIVESTOCK OR AGROALIMENTARY INDUSTRIES	TECHNOLOGIES IN THE PRODUCTION PROCESS FOR FINAL INDUSTRIAL OR CONSUMER PRODUCTS	CLIMATE CHANGE MITIGATION TECHNOLOGIES FOR SECTOR-WIDE APPLICATIONS	ENABLING TECHNOLOGIES WITH A POTENTIAL CONTRIBUTION TO GHG EMISSIONS MITIGATION
		Y02P	**Y02P 10**	**Y02P 20**	**Y02P 30**	**Y02P 40**	**Y02P 60**	**Y02P 70**	**Y02P 80**	**Y02P 90**
WORLD		24644	3521	8932	1275	1493	965	6062	501	2744
NORDIC Countries (DK, FI, NO, SE) CNTRY		1658	235	430	125	58	89	575	65	133
Denmark	**DK**	662	9	148	24	24	40	391	21	14
Finland	**FI**	423	97	136	76	19	28	56	12	23
Norway	**NO**	175	26	61	14	2	5	45	5	26
Sweden	**SE**	442	107	107	16	14	20	91	28	71

Table A 5 - Distribution of Climate Change Mitigation (CCM) Technologies related to PRODUCTION and PROCESSING of goods (Y02P, and subgroups)

	NUTS-2 Region	Code	Y02P 10	Y02P 20	Y02P 30	Y02P 40	Y02P 60	Y02P 70	Y02P 80	Y02P 90	Y02P
Denmark	DK_not regionalised	DK	0	2	2	0	2	9	1	0	16
	Hovedstaden	DK01	3	99	18	13	11	40	1	2	187
	Sjælland	DK02	0	12	1	8	5	20	2	1	47
	Syddanmark	DK03	3	13	0	0	9	135	6	6	170
	Midtjylland	DK04	3	10	2	1	10	163	10	4	201
	Nordjylland	DK05	0	5	1	4	2	20	2	1	35
	Not regionalised	DKXX	0	1	0	0	0	3	1	0	4
	Not classified	DKZZ	1	2	0	0	0	2	0	0	4
Finland	FI_not regionalised	FI	1	0	0	0	0	1	1	0	3
	Länsi-Suomi	FI19	40	22	6	10	6	14	3	11	112
	Helsinki-Uusimaa	FI1B	37	85	59	4	12	28	6	9	238
	Etelä-Suomi	FI1C	7	15	11	4	7	6	2	2	53
	Pohjois- ja Itä-Suomi	FI1D	11	11	0	1	1	7	1	2	34
	Åland	FI20	0	1	0	0	0	0	0	0	1
	Not regionalised	FIXX	0	0	0	0	1	1	0	0	1
	Not classified	FIZZ	0	0	0	1	0	0	0	0	1
Norway	NO_not regionalised	NO	0	1	0	0	0	1	0	0	2
	Oslo og Akershus	NO01	12	18	2	1	0	11	2	8	52
	Hedmark og Oppland	NO02	1	1	0	0	0	0	0	0	2
	Sør-Østlandet	NO03	5	15	2	0	0	10	0	1	32
	Agder og Rogaland	NO04	1	4	3	1	2	9	2	8	30
	Vestlandet	NO05	2	9	4	0	3	3	1	6	27
	Trøndelag	NO06	4	10	1	0	0	7	0	4	26
	Nord-Norge	NO07	0	1	1	0	0	1	0	0	3
	Not regionalised	NOXX	0	0	0	0	0	1	0	0	2
	Not classified	NOZZ	0	0	0	0	0	1	0	0	1
Sweden	SE_not regionalised	SE	2	2	0	0	1	2	0	2	9
	Stockholm	SE11	22	29	1	5	4	16	4	7	87
	Östra Mellansverige	SE12	24	15	3	1	1	27	16	35	122
	Småland med öarna	SE21	2	4	0	0	0	2	2	3	13

	Sydsverige	**SE22**	7	29	4	1	5	14	0	7	66
	Västsverige	**SE23**	30	10	3	3	3	13	1	10	72
	Norra Mellansverige	**SE31**	7	2	0	3	0	3	0	2	17
	Mellersta Norrland	**SE32**	0	0	0	0	4	5	1	0	10
	Övre Norrland	**SE33**	10	3	2	2	2	4	3	3	27
	Not regionalised	**SEXX**	1	2	1	0	0	1	1	3	6
	Not classified	**SEZZ**	0	2	1	0	0	1	1	0	4

Table A 6 - - Distribution of Climate Change Mitigation (CCM) Technologies related to TRANSPORT (Y02T, and subgroups) across Nordic countries

		CLIMATE CHANGE MITIGATION technologies related to TRANSPORTATION	**ROAD TRANSPORT**	**RAIL TRANSPORT**	**AIR TRANSPORT**	**MARITIME OR WATERWAYS TRANSPORT**	**ENABLING TECHNOLOGIES IN TRANSPORT**
		Y02T	**Y02T 10**	**Y02T 30**	**Y02T 50**	**Y02T 70**	**Y02T 90**
WORLD		36293	25371	298	8107	418	2258
NORDIC CNTRY (DK, FI, NO, SE)		1357	1140	7	123	86	116
Denmark	**DK**	130	96	0	19	12	9
Finland	**FI**	256	208	1	14	36	24
Norway	**NO**	57	30	0	5	25	2
Sweden	**SE**	941	831	6	85	15	83

Table A 7 - Distribution of Climate Change Mitigation (CCM) Technologies related to Transport (Y02T, and subgroups)

	NUTS-2 Region	**Code**	**Y02T 10**	**Y02T 30**	**Y02T 50**	**Y02T 70**	**Y02T 90**	**Y02T**
Denmark	**DK_not regionalised**	**DK**	1	0	0	1	0	2
	Hovedstaden	**DK01**	52	0	1	6	3	63
	Sjælland	**DK02**	4	0	1	0	2	8
	Syddanmark	**DK03**	5	0	11	1	1	17
	Midtjylland	**DK04**	13	0	3	2	2	20
	Nordjylland	**DK05**	8	0	1	1	0	10
	Not regionalised	**DKXX**	2	0	0	1	0	3

	Not classified	**DKZZ**	1	0	1	0	0	2
Finland	**FI_not regionalised**	**FI**	2	0	0	0	0	2
	Länsi-Suomi	**FI19**	136	0	3	4	12	154
	Helsinki-Uusimaa	**FI1B**	31	1	8	16	7	62
	Etelä-Suomi	**FI1C**	26	0	2	15	5	48
	Pohjois- ja Itä-Suomi	**FI1D**	11	0	1	1	1	15
	Åland	**FI20**	1	0	0	0	0	1
	Not regionalised	**FIXX**	1	0	0	0	0	1
	Not classified	**FIZZ**	0	0	0	0	0	0
Norway	**NO_not regionalised**	**NO**	2	0	1	1	0	4
	Oslo og Akershus	**NO01**	6	0	2	6	0	13
	Hedmark og Oppland	**NO02**	0	0	0	0	0	0
	Sør-Østlandet	**NO03**	8	0	0	3	0	11
	Agder og Rogaland	**NO04**	3	0	1	2	0	6
	Vestlandet	**NO05**	8	0	0	10	2	20
	Trøndelag	**NO06**	2	0	0	3	0	4
	Nord-Norge	**NO07**	2	0	0	0	0	2
	Not regionalised	**NOXX**	1	0	0	0	0	1
	Not classified	**NOZZ**	0	0	0	0	0	0
Sweden	**SE_not regionalised**	**SE**	12	0	0	1	3	16
	Stockholm	**SE11**	264	2	7	3	14	289
	Östra Mellansverige	**SE12**	83	0	31	1	17	132
	Småland med öarna	**SE21**	34	1	0	0	18	53
	Sydsverige	**SE22**	40	1	4	2	3	50
	Västsverige	**SE23**	351	1	40	7	23	421
	Norra Mellansverige	**SE31**	7	1	0	1	0	9
	Mellersta Norrland	**SE32**	12	0	1	0	2	14
	Övre Norrland	**SE33**	3	0	1	0	1	5
	Not regionalised	**SEXX**	13	0	3	0	3	18
	Not classified	**SEZZ**	1	0	0	0	0	1

Table A 8 - Distribution of Climate Change Mitigation (CCM) Technologies related to BUILDINGS (Y02B, and subgroups) across Nordic countries

	NUTS	**CLIMATE CHANGE MITIGATION technologies related to BUILDINGS**	**INTEGRATION OF RENEWABLE ENERGY SOURCES IN BUILDINGS**	**ENERGY EFFICIENCY IN BUILDINGS; Lightning**	**ENERGY EFFICIENCY IN BUILDINGS; Heating, ventilation or air**	**ENERGY EFFICIENCY IN BUILDINGS; Home appliances**	**ENERGY EFFICIENCY IN BUILDINGS; Elevators, escalators and**	**ENERGY EFFICIENCY IN BUILDINGS; Information and**	**ENERGY EFFICIENCY IN BUILDINGS; End-user side**	**ARCHITECTURAL OR CONSTRUCTIONAL ELEMENTS**	**ENABLING TECHNOLOGIES IN BUILDINGS**
		Y02B	**Y02B 10**	**Y02B 20**	**Y02B 30**	**Y02B 40**	**Y02B 50**	**Y02B 60**	**Y02B 70**	**Y02B 80**	**Y02B 90**
WORLD		21598	1780	2810	3002	853	68	9094	2483	360	1150
NORDIC CNTRY (DK, FI, NO, SE)		1444	165	56	216	19	18	828	125	8	54
Denmark	DK	286	63	21	94	5	0	254	50	2	13
Finland	FI	438	23	15	37	3	15	177	24	1	14
Norway	NO	83	28	3	12	1	0	71	12	0	6
Sweden	SE	681	55	18	77	10	4	340	43	6	21

Table A 9 - Distribution of Climate Change Mitigation (CCM) Technologies related to Buildings (Y02B, and subgroups)

	NUTS-2 Region	Code	**Y02B 10**	**Y02B 20**	**Y02B 30**	**Y02B 40**	**Y02B 50**	**Y02B 60**	**Y02B 70**	**Y02B 80**	**Y02B 90**	**Y02B**
Denmark	DK_not regionalised	DK	2	1	2	0	0	2	2	0	0	9
	Hovedstaden	DK01	23	4	15	1	0	10	8	1	3	63
	Sjælland	DK02	3	4	3	0	0	3	1	2	1	17
	Syddanmark	DK03	20	0	20	0	0	5	12	3	3	61
	Midtjylland	DK04	31	8	31	0	0	5	7	0	17	99
	Nordjylland	DK05	4	1	5	0	0	23	2	1	3	38
	Not regionalised	DKXX	2	0	2	0	0	1	0	0	0	4
	Not classified	DKZZ	1	0	0	0	0	0	1	0	0	1
Finland	FI_not regionalised	FI	0	0	0	1	0	1	0	0	0	2
	Länsi-Suomi	FI19	7	1	8	1	0	65	2	0	2	86
	Helsinki-Uusimaa	FI1B	8	12	19	0	17	151	13	0	6	226
	Etelä-Suomi	FI1C	2	8	9	0	0	33	4	0	0	56
	Pohjois- ja Itä-Suomi	FI1D	1	0	3	0	0	51	1	0	1	57
	Åland	FI20	0	0	2	0	0	1	0	0	0	3
	Not regionalised	FIXX	0	0	0	0	0	1	0	0	0	1
	Not classified	FIZZ	0	0	0	0	0	0	0	0	0	0
Norway	NO_not regionalised	NO	2	0	1	0	0	0	1	0	0	4
	Oslo og Akershus	NO01	6	0	6	0	0	8	9	1	2	31
	Hedmark og Oppland	NO02	0	0	0	0	0	0	0	0	0	0
	Sør-Østlandet	NO03	2	1	2	0	0	1	1	1	0	8
	Agder og Rogaland	NO04	9	0	5	0	0	4	2	0	0	20
	Vestlandet	NO05	2	1	3	0	0	2	2	0	2	11
	Trøndelag	NO06	0	0	1	0	0	5	2	0	0	8
	Nord-Norge	NO07	0	0	3	0	0	0	0	0	0	3
	Not regionalised	NOXX	0	0	1	0	0	0	0	0	0	1
	Not classified	NOZZ	0	0	0	0	0	0	0	0	0	0
Sweden	SE_not regionalised	SE	1	2	3	0	0	12	5	0	0	23
	Stockholm	SE11	15	6	25	14	1	210	13	0	6	289

	Östra Mellansverige	SE12	3	2	5	0	0	47	13	0	6	74
	Småland med öarna	SE21	6	1	13	2	0	2	14	0	0	38
	Sydsverige	SE22	2	4	8	0	0	118	4	0	2	137
	Västsverige	SE23	7	1	10	0	0	38	5	0	1	61
	Norra Mellansverige	SE31	4	0	11	0	0	3	2	0	1	21
	Mellersta Norrland	SE32	3	0	2	0	0	1	0	0	0	6
	Övre Norrland	SE33	1	1	1	0	0	20	2	0	0	25
	Not regionalised	SEXX	1	0	1	0	0	1	0	0	0	2
	Not classified	SEZZ	0	0	0	0	0	6	0	0	0	6

Table A 10 - Revealed Technological Advantages across CCM technologies, based on patent families, applied to EPO, year: 2000-2014 and fractional counts based on inventors' addresses

			CLIMATE CHANGE MITIGATION technologies related to BUILDINGS	CAPTURE, STORAGE, SEQUESTRATION OR DISPOSAL	CCM related to ENERGY	CLIMATE CHANGE MITIGATION TECHNOLOGIES IN THE	CLIMATE CHANGE MITIGATION technologies related to	CLIMATE CHANGE MITIGATION technologies related to	
	NUTS-2 Region	Code	Y02B	Y02C	Y02E	Y02P	Y02T	Y02W	Count of RTA> 0
Denmark	**DK_not regionalised**	**DK**	-0.20	-1.00	0.19	0.04	-0.66	-0.23	2
	Hovedstaden	**DK01**	-0.27	-0.34	0.05	0.20	-0.14	-0.22	2
	Sjælland	**DK02**	-0.19	-1.00	0.00	0.24	-0.48	0.24	3
	Syddanmark	**DK03**	-0.35	-0.22	0.23	0.05	-0.72	-0.76	2
	Midtjylland	**DK04**	-0.38	-0.95	0.29	-0.13	-0.81	-0.54	1
	Nordjylland	**DK05**	0.15	-1.00	0.08	0.00	-0.38	-0.26	2
	Not regionalised	**DKXX**	-0.23	-1.00	0.23	-0.19	-0.18	-0.60	1
	Not classified	**DKZZ**	-0.46	-1.00	0.15	0.10	0.03	-1.00	3
Finland	**FI_not regionalised**	**FI**	-0.07	-1.00	0.10	0.04	0.04	-1.00	3
	Länsi-Suomi	**FI19**	0.02	-0.65	-0.30	0.07	0.38	0.09	4
	Helsinki-Uusimaa	**FI1B**	0.29	-0.66	-0.18	0.19	-0.27	-0.15	2

	Etelä-Suomi	**FI1C**	0.16	-0.65	-0.24	0.03	0.11	0.36	4
	Pohjois- ja Itä-Suomi	**FI1D**	0.36	-0.41	-0.27	0.02	-0.22	0.27	3
	Åland	**FI20**	0.46	-1.00	-0.13	-0.43	0.09	-1.00	2
	Not regionalised	**FIXX**	-0.03	-1.00	0.14	-0.13	0.08	-1.00	2
	Not classified	**FIZZ**	-1.00	-1.00	0.08	0.29	-1.00	0.42	3
	NO_not regionalised	**NO**	-0.10	0.06	0.13	-0.50	0.00	0.21	4
	Oslo og Akershus	**NO01**	-0.11	0.61	0.02	0.07	-0.44	-0.27	3
	Hedmark og Oppland	**NO02**	-1.00	0.65	0.25	-0.18	-1.00	-0.17	2
	Sør-Østlandet	**NO03**	-0.45	0.70	-0.05	0.11	-0.23	0.04	3
	Agder og Rogaland	**NO04**	-0.05	0.29	0.01	0.12	-0.45	0.11	4
	Vestlandet	**NO05**	-0.25	0.20	-0.01	0.07	0.10	0.02	4
	Trøndelag	**NO06**	-0.31	0.70	0.00	0.13	-0.49	-0.35	3
	Nord-Norge	**NO07**	-0.13	0.26	0.17	-0.25	-0.27	-0.12	2
	Not regionalised	**NOXX**	-0.13	0.43	0.00	0.09	-0.28	0.07	4
Norway	**Not classified**	**NOZZ**	-1.00	-1.00	-0.24	0.11	-1.00	0.77	2
	SE_not regionalised	**SE**	0.42	-1.00	-0.44	-0.12	0.30	-0.30	2
	Stockholm	**SE11**	0.37	-0.63	-0.45	-0.30	0.44	-0.33	2
	Östra Mellansverige	**SE12**	-0.15	-0.49	0.06	-0.02	0.19	-0.53	2
	Småland med öarna	**SE21**	0.27	0.51	-0.31	-0.31	0.36	-0.55	3
	Sydsverige	**SE22**	0.39	-0.27	-0.25	-0.06	-0.02	-0.04	1
	Västsverige	**SE23**	-0.26	-0.66	-0.55	-0.28	0.66	-0.46	1
	Norra Mellansverige	**SE31**	-0.07	0.11	0.15	-0.22	-0.34	0.08	3
	Mellersta Norrland	**SE32**	-0.14	-1.00	-0.02	0.02	0.30	-0.36	2
	Övre Norrland	**SE33**	0.22	-0.47	-0.15	0.18	-0.51	0.22	3
	Not regionalised	**SEXX**	-0.44	-1.00	-0.20	-0.07	0.52	0.02	2
Sweden	**Not classified**	**SEZZ**	0.28	-1.00	0.03	-0.10	-0.64	0.07	3

Table A 11- - Revealed Technological Advantages for CCM Technologies related to ENERGY (Y02E, and subgroups) across Nordic countries

	NUTS-2 Region	Code	Y02E 10	Y02E 20	Y02E 30	Y02E 40	Y02E 50	Y02E 60	Y02E 70
Denmark	DK_not regionalised	DK	0 .27	-0 .39	-1 .00	-1 .00	-0 .56	-0 .75	-1 .00
	Hovedstaden	DK01	-0 .20	-0 .36	-1 .00	-0 .21	0 .44	0 .03	-0 .50
	Sjælland	DK02	0 .06	-0 .43	-1 .00	-0 .71	-0 .13	0 .22	0 .08
	Syddanmark	DK03	0 .25	-0 .52	-1 .00	-0 .41	-0 .59	-0 .43	-0 .57
	Midtjylland	DK04	0 .29	-0 .92	-1 .00	-0 .05	-0 .77	-0 .80	-0 .41
	Nordjylland	DK05	0 .24	-0 .64	-1 .00	-0 .25	-0 .52	-0 .55	0 .20
	Not regionalised	DKXX	0 .18	-0 .62	-1 .00	0 .21	-0 .05	-0 .66	-1 .00
	Not classified	DKZZ	-0 .60	-1 .00	-1 .00	-1 .00	0 .69	-1 .00	-1 .00
Finland	FI_not regionalised	FI	0 .11	0 .10	-1 .00	-1 .00	-1 .00	-0 .11	0 .80
	Länsi-Suomi	FI19	-0 .23	0 .39	-1 .00	0 .33	0 .23	-0 .18	-1 .00
	Helsinki-Uusimaa	FI1B	-0 .10	-0 .14	-0 .09	-0 .38	0 .29	0 .07	-0 .21
	Etelä-Suomi	FI1C	-0 .37	0 .10	-1 .00	0 .01	0 .48	-0 .03	-1 .00
	Pohjois- ja Itä-Suomi	FI1D	-0 .27	0 .60	-1 .00	-1 .00	0 .22	-0 .53	-1 .00
	Åland	FI20	-0 .50	-1 .00	-1 .00	-1 .00	-1 .00	0 .62	0 .85
	Not regionalised	FIXX	-1 .00	0 .70	-1 .00	0 .72	-1 .00	-0 .04	-1 .00
	Not classified	FIZZ	0 .33	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
Norway	NO_not regionalised	NO	0 .15	-1 .00	0 .77	-1 .00	0 .08	-1 .00	-1 .00
	Oslo og Akershus	NO01	0 .10	-0 .32	-1 .00	-0 .32	-0 .21	0 .11	-0 .14
	Hedmark og Oppland	NO02	-0 .13	-1 .00	-1 .00	-1 .00	-0 .08	0 .51	-1 .00
	Sør-Østlandet	NO03	-0 .32	0 .43	-1 .00	0 .06	-0 .09	0 .31	-1 .00
	Agder og Rogaland	NO04	0 .18	-0 .44	-1 .00	-0 .01	-0 .53	-0 .07	-1 .00
	Vestlandet	NO05	0 .16	-0 .30	-1 .00	-1 .00	0 .05	-0 .40	-1 .00
	Trøndelag	NO06	0 .12	-0 .60	-1 .00	0 .40	-0 .52	0 .06	-1 .00
	Nord-Norge	NO07	0 .29	-1 .00	-1 .00	-1 .00	-1 .00	-0 .28	-1 .00
	Not regionalised	NOXX	-0 .02	0 .28	-1 .00	0 .68	-0 .27	-1 .00	-1 .00
	Not classified	NOZZ	0 .33	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
Sweden	SE_not regionalised	SE	-0 .30	-1 .00	0 .70	0 .32	-1 .00	0 .49	0 .73
	Stockholm	SE11	-0 .08	0 .09	0 .04	-0 .19	-0 .10	0 .21	0 .31

	Östra Mellansverige	SE12	-0 .23	-0 .06	0 .83	0 .62	-0 .51	0 .04	-1 .00
	Småland med öarna	SE21	-0 .32	0 .58	-1 .00	0 .29	-0 .14	-0 .13	0 .43
	Sydsverige	SE22	-0 .17	0 .05	-1 .00	0 .08	0 .34	-0 .03	-1 .00
	Västsverige	SE23	0 .06	-0 .22	0 .31	-0 .41	-0 .24	0 .16	-1 .00
	Norra Mellansverige	SE31	-0 .28	-0 .51	-0 .19	-0 .34	-0 .68	0 .60	-1 .00
	Mellersta Norrland	SE32	-0 .04	-0 .33	-1 .00	-1 .00	0 .38	-0 .09	-1 .00
	Övre Norrland	SE33	-0 .35	0 .31	-1 .00	-1 .00	0 .53	-0 .63	-1 .00
	Not regionalised	SEXX	-0 .28	0 .42	0 .79	0 .03	0 .12	-0 .34	-1 .00
	Not classified	SEZZ	0 .02	0 .05	-1 .00	0 .12	0 .08	-0 .16	-1 .00

Table A 12 - Revealed Technological Advantages for CCM Technologies related to PRODUCTION and PROCESSING of goods (Y02P, and subgroups) across Nordic countries

	NUTS-2 Region	Code	Y02P 10	Y02P 20	Y02P 30	Y02P 40	Y02P 60	Y02P 70	Y02P 80	Y02P 90
	DK_not regionalised	DK	-1 .00	-0 .33	0 .36	-1 .00	0 .37	0 .27	0 .11	-1 .00
	Hovedstaden	DK01	-0 .80	0 .36	0 .24	0 .21	0 .03	-0 .19	-0 .90	-0 .76
	Sjælland	DK02	-1 .00	0 .00	-0 .47	0 .57	0 .29	0 .13	-0 .22	-0 .55
	Syddanmark	DK03	-0 .82	-0 .53	-1 .00	-1 .00	-0 .05	0 .42	-0 .22	-0 .39
	Midtjylland	DK04	-0 .85	-0 .67	-0 .77	-0 .89	-0 .07	0 .43	-0 .03	-0 .55
	Nordjylland	DK05	-1 .00	-0 .27	-0 .60	0 .40	0 .01	0 .29	0 .07	-0 .31
	Not regionalised	DKXX	-1 .00	-0 .35	-1 .00	-1 .00	-1 .00	0 .33	0 .65	-1 .00
Denmark	Not classified	DKZZ	0 .26	0 .20	-1 .00	-1 .00	-1 .00	0 .08	-1 .00	-1 .00
	FI_not regionalised	FI	0 .38	-1 .00	-1 .00	-1 .00	-1 .00	0 .02	0 .74	-1 .00
	Länsi-Suomi	FI19	0 .41	-0 .12	-0 .03	0 .32	0 .00	-0 .43	-0 .30	0 .14
	Helsinki-Uusimaa	FI1B	0 .02	0 .18	0 .62	-0 .44	-0 .05	-0 .47	-0 .37	-0 .32
	Etelä-Suomi	FI1C	-0 .02	0 .05	0 .57	0 .21	0 .42	-0 .50	-0 .27	-0 .44
	Pohjois- ja Itä-Suomi	FI1D	0 .36	0 .15	-1 .00	-0 .19	-0 .31	-0 .20	-0 .26	-0 .25
	Åland	FI20	-1 .00	0 .60	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
	Not regionalised	FIXX	-1 .00	-1 .00	-1 .00	-1 .00	0 .80	0 .22	-1 .00	-1 .00
Finland	Not classified	FIZZ	0 .38	-1 .00	-1 .00	0 .88	-1 .00	-1 .00	-1 .00	-1 .00

	NO_not regionalised	**NO**	-1 .00	0 .34	-1 .00	-1 .00	-1 .00	0 .22	-1 .00	-1 .00
	Oslo og Akershus	**NO01**	0 .20	0 .16	-0 .21	-0 .39	-1 .00	-0 .22	-0 .27	0 .32
	Hedmark og Oppland	**NO02**	0 .64	0 .15	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
	Sør-Østlandet	**NO03**	0 .01	0 .31	-0 .03	-1 .00	-1 .00	-0 .03	-1 .00	-0 .65
	Agder og Rogaland	**NO04**	-0 .54	-0 .32	0 .26	-0 .13	0 .08	-0 .05	0 .15	0 .57
	Vestlandet	**NO05**	-0 .33	0 .15	0 .43	-1 .00	0 .24	-0 .48	-0 .15	0 .47
	Trøndelag	**NO06**	-0 .03	0 .23	-0 .21	-1 .00	-1 .00	-0 .08	-1 .00	0 .35
	Nord-Norge	**NO07**	-1 .00	0 .09	0 .67	-1 .00	-1 .00	0 .11	-1 .00	-1 .00
	Not regionalised	**NOXX**	-1 .00	-0 .29	0 .40	-1 .00	-1 .00	0 .39	-1 .00	-1 .00
Norway	**Not classified**	**NOZZ**	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	0 .51	-1 .00	-1 .00
	SE_not regionalised	**SE**	0 .20	-0 .06	-1 .00	-1 .00	0 .32	-0 .18	-1 .00	0 .50
	Stockholm	**SE11**	0 .25	0 .14	-0 .74	0 .13	-0 .13	-0 .27	-0 .04	0 .04
	Östra Mellansverige	**SE12**	0 .15	-0 .33	-0 .44	-0 .83	-0 .79	-0 .18	0 .44	0 .59
	Småland med öarna	**SE21**	0 .09	0 .10	-1 .00	-1 .00	-1 .00	-0 .29	0 .50	0 .44
	Sydsverige	**SE22**	-0 .17	0 .28	-0 .03	-0 .70	0 .14	-0 .20	-1 .00	0 .14
	Västsverige	**SE23**	0 .47	-0 .29	-0 .25	-0 .03	-0 .18	-0 .28	-0 .69	0 .32
	Norra Mellansverige	**SE31**	0 .49	-0 .36	-1 .00	0 .59	-1 .00	-0 .25	-1 .00	0 .08
	Mellersta Norrland	**SE32**	-1 .00	-1 .00	-1 .00	-0 .28	0 .75	0 .21	0 .32	-1 .00
	Övre Norrland	**SE33**	0 .43	-0 .38	0 .03	0 .13	-0 .01	-0 .42	0 .36	0 .18
	Not regionalised	**SEXX**	-0 .31	-0 .02	0 .15	-1 .00	-1 .00	-0 .60	0 .45	0 .69
Sweden	**Not classified**	**SEZZ**	-1 .00	0 .23	0 .68	-1 .00	-1 .00	-0 .35	0 .45	-1 .00

Table A 13 - Revealed Technological Advantages for CCM Technologies related to TRANSPORT (Y02T, and subgroups) across Nordic countries

	NUTS-2 Region	Code	Y02T 10	Y02T 30	Y02T 50	Y02T 70	Y02T 90
Denmark	DK_not regionalised	DK	-0 .12	-1 .00	-1 .00	0 .61	-1 .00
	Hovedstaden	DK01	0 .13	-1 .00	-0 .63	-0 .11	-0 .10
	Sjælland	DK02	-0 .06	-1 .00	0 .30	-1 .00	0 .63
	Syddanmark	DK03	-0 .42	-1 .00	0 .74	-0 .35	-0 .01
	Midtjylland	DK04	0 .01	-1 .00	0 .28	-0 .23	0 .26
	Nordjylland	DK05	0 .12	-1 .00	-0 .07	-0 .10	-1 .00
	Not regionalised	DKXX	0 .00	-1 .00	-1 .00	0 .49	-1 .00
	Not classified	DKZZ	-0 .20	-1 .00	0 .72	-1 .00	-1 .00
Finland	FI_not regionalised	FI	0 .22	-1 .00	-1 .00	-1 .00	-1 .00
	Länsi-Suomi	FI19	0 .16	-1 .00	-0 .69	-0 .64	0 .12
	Helsinki-Uusimaa	FI1B	-0 .13	0 .54	0 .14	0 .37	0 .28
	Etelä-Suomi	FI1C	-0 .08	-1 .00	-0 .31	0 .43	0 .28
	Pohjois- ja Itä-Suomi	FI1D	0 .09	-1 .00	-0 .02	-0 .28	0 .07
	Åland	FI20	0 .22	-1 .00	-1 .00	-1 .00	-1 .00
	Not regionalised	FIXX	0 .22	-1 .00	-1 .00	-1 .00	-1 .00
	Not classified	FIZZ	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
Norway	NO_not regionalised	NO	-0 .12	-1 .00	0 .45	0 .35	-1 .00
	Oslo og Akershus	NO01	-0 .21	-1 .00	0 .24	0 .56	-1 .00
	Hedmark og Oppland	NO02	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
	Sør-Østlandet	NO03	0 .05	-1 .00	-0 .52	0 .38	-1 .00
	Agder og Rogaland	NO04	-0 .20	-1 .00	0 .42	0 .48	-1 .00
	Vestlandet	NO05	-0 .23	-1 .00	-1 .00	0 .61	0 .26
	Trøndelag	NO06	-0 .30	-1 .00	-0 .10	0 .66	-1 .00
	Nord-Norge	NO07	0 .22	-1 .00	-1 .00	-1 .00	-1 .00
	Not regionalised	NOXX	0 .22	-1 .00	-1 .00	-1 .00	-1 .00
	Not classified	NOZZ	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
Sweden	SE_not regionalised	SE	0 .08	-1 .00	-1 .00	-0 .32	0 .52
	Stockholm	SE11	0 .17	0 .18	-0 .61	-0 .84	-0 .10
	Östra Mellansverige	SE12	-0 .01	-1 .00	0 .43	-0 .88	0 .37
	Småland med öarna	SE21	0 .01	0 .60	-1 .00	-1 .00	0 .70
	Sydsverige	SE22	0 .11	0 .61	-0 .08	-0 .50	0 .01
	Västsverige	SE23	0 .13	-0 .34	0 .00	-0 .76	-0 .05
	Norra Mellansverige	SE31	0 .09	0 .92	-1 .00	-0 .03	-1 .00
	Mellersta Norrland	SE32	0 .14	-1 .00	-0 .43	-1 .00	0 .31
	Övre Norrland	SE33	-0 .03	-1 .00	0 .36	-1 .00	0 .54

	Not regionalised	**SEXX**	0 .06	-1 .00	0 .19	-1 .00	0 .40
	Not classified	**SEZZ**	0 .22	-1 .00	-1 .00	-1 .00	-1 .00

Table A 14: Revealed Technological Advantages for CCM Technologies related to BUILDINGS (Y02B, and subgroups) across Nordic countries

	NUTS-2 Region	**Code**	**Y02B 10**	**Y02B 20**	**Y02B 30**	**Y02B 40**	**Y02B 50**	**Y02B 60**	**Y02B 70**	**Y02B 80**	**Y02B 90**
Denmark	**DK_not regionalised**	**DK**	0 .15	0 .56	0 .03	-1 .00	-1 .00	-0 .24	0 .39	-1 .00	-1 .00
	Hovedstaden	**DK01**	0 .38	0 .28	0 .05	-0 .03	-1 .00	-0 .38	0 .09	-0 .24	0 .32
	Sjælland	**DK02**	0 .10	0 .77	-0 .16	-1 .00	-1 .00	-0 .28	-0 .24	0 .75	0 .37
	Syddanmark	**DK03**	0 .33	-1 .00	0 .22	-1 .00	-1 .00	-0 .66	0 .31	0 .52	0 .36
	Midtjylland	**DK04**	0 .32	0 .41	0 .21	-1 .00	-1 .00	-0 .75	-0 .16	-1 .00	0 .76
	Nordjylland	**DK05**	-0 .27	-0 .08	-0 .20	-1 .00	-1 .00	0 .26	-0 .42	0 .02	0 .49
	Not regionalised	**DKXX**	0 .37	-1 .00	0 .43	-1 .00	-1 .00	-0 .50	-1 .00	-1 .00	-1 .00
	Not classified	**DKZZ**	0 .51	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	0 .67	-1 .00	-1 .00
Finland	**FI_not regionalised**	**FI**	-1 .00	-1 .00	-1 .00	0 .93	-1 .00	0 .16	-1 .00	-1 .00	-1 .00
	Länsi-Suomi	**FI19**	-0 .34	-0 .46	-0 .37	-0 .19	-1 .00	0 .35	-0 .62	-1 .00	0 .08
	Helsinki-Uusimaa	**FI1B**	-0 .64	0 .26	-0 .42	-1 .00	0 .95	0 .30	-0 .28	-1 .00	0 .10
	Etelä-Suomi	**FI1C**	-0 .64	0 .64	-0 .13	-1 .00	-1 .00	0 .24	-0 .23	-0 .37	-0 .59
	Pohjois- ja Itä-Suomi	**FI1D**	-0 .81	-1 .00	-0 .56	-1 .00	-1 .00	0 .42	-0 .70	-1 .00	-0 .14
	Åland	**FI20**	-1 .00	-1 .00	0 .44	-1 .00	-1 .00	0 .13	-1 .00	-1 .00	-1 .00
	Not regionalised	**FIXX**	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	0 .47	-1 .00	-1 .00	-1 .00
	Not classified	**FIZZ**	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
Norway	**NO_not regionalised**	**NO**	0 .51	-1 .00	0 .09	-1 .00	-1 .00	-1 .00	0 .43	-1 .00	-1 .00
	Oslo og Akershus	**NO01**	0 .07	-1 .00	-0 .04	-1 .00	-1 .00	-0 .20	0 .50	0 .43	0 .35
	Hedmark og Oppland	**NO02**	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
	Sør-Østlandet	**NO03**	0 .08	0 .60	0 .10	-1 .00	-1 .00	-0 .48	0 .27	0 .82	-1 .00
	Agder og Rogaland	**NO04**	0 .48	-1 .00	0 .05	-1 .00	-1 .00	-0 .28	0 .02	-1 .00	-1 .00

	Vestlandet	**NO05**	0 .05	0 .49	0 .05	-1 .00	-1 .00	-0 .33	0 .16	-1 .00	0 .77
	Trøndelag	**NO06**	-0 .61	-1 .00	-0 .27	-1 .00	-1 .00	0 .25	0 .42	-1 .00	-1 .00
	Nord-Norge	**NO07**	-1 .00	-1 .00	0 .66	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
	Not regionalised	**NOXX**	0 .42	-1 .00	0 .49	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
	Not classified	**NOZZ**	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00
	SE_not regionalised	**SE**	-0 .58	0 .47	-0 .23	-1 .00	-1 .00	0 .18	0 .38	-1 .00	-1 .00
	Stockholm	**SE11**	-0 .52	-0 .21	-0 .42	0 .48	0 .24	0 .33	-0 .36	-1 .00	-0 .10
	Östra Mellansverige	**SE12**	-0 .66	-0 .21	-0 .51	-1 .00	-1 .00	0 .27	0 .26	-1 .00	0 .53
	Småland med öarna	**SE21**	-0 .01	-0 .41	0 .25	0 .52	-1 .00	-0 .73	0 .58	-1 .00	-1 .00
	Sydsverige	**SE22**	-0 .87	-0 .04	-0 .56	-1 .00	-1 .00	0 .41	-0 .54	-1 .00	-0 .23
	Västsverige	**SE23**	-0 .21	-0 .32	-0 .12	-1 .00	-1 .00	0 .27	-0 .09	-1 .00	-0 .48
	Norra Mellansverige	**SE31**	0 .02	-1 .00	0 .44	-1 .00	-1 .00	-0 .45	-0 .01	0 .11	0 .35
	Mellersta Norrland	**SE32**	0 .51	-1 .00	0 .23	-1 .00	-1 .00	-0 .37	-1 .00	-1 .00	-1 .00
	Övre Norrland	**SE33**	-0 .60	0 .13	-0 .67	-1 .00	-1 .00	0 .38	-0 .10	-1 .00	-1 .00
	Not regionalised	**SEXX**	0 .45	-1 .00	0 .02	-100	-1 .00	-0 .26	-1 .00	0 .83	-1 .00
Sweden	**Not classified**	**SEZZ**	-1 .00	-1 .00	-1 .00	-1 .00	-1 .00	0 .47	-1 .00	-1 .00	-1 .00

Table A 15 - Discrepancy in the values due to fractional counts

	Y02B	**Y02C**	**Y02E**	**Y02P**	**Y02T**	**Y02W**
Denmark	286	25	1949	662	130	84
DK /Regional sum	278	25	1937	653	119	83
DK /Y sub-groups sum	299		2037	671	136	
DK / Regional+Y sub-groups sum	291		2026	664	125	
Finland	438	11	435	423	256	128
FI /Regional sum	419	11	427	418	255	126
FI /Y sub-groups sum	450		459	447	283	
FI / Regional+Y sub-groups sum	432		451	442	282	
Norway	83	79	315	175	57	44
NO /Regional sum	80	79	306	167	55	43
NO/Y sub-groups sum	89		324	184	62	
NO / Regional+Y sub-groups sum	85		316	176	61	

Sweden	681	40	763	442	941	110
SE /Regional sum	667	39	737	421	929	105
SE /Y sub-groups sum	696		792	454	1020	
SE / Regional+Y sub-groups sum	682		767	434	1008	

*** Ctry>Y sub-group>CTRY> Regional. For example: DKY02B > SUM OF DK Y02B REGIONS> SUM OF DK Y02B SUB-GROUPS.**

Appendix D

In the comparison (1.3.1), all subcategories of the following headings are used. However, those subcategories with an asterisk (*) are the most obvious candidates for future work.

For a description of the Y-tag system, see https://www.epo.org/news-issues/issues/classification/classification.html

Below is an overview of the subcategories of the SGC used in Chapter 1 with asterisks next to the categories that we nominated as potentially most relevant.

<u>A. Social Grand Challenges (Freitsch et al)</u>

sgc_1: health

- e-health
- medical instruments
- OECD biotech definition(health) *
- pharmaceuticals

sgc_2: food, agriculture, bioeconomy

- (future) proteins
- agriculture/forestry
- animals/livestock mngmnt
- biomass from green inventory *
- bio-materials *
- food
- genetic engineering
- household appliances (food-related)
- landscape management
- machines (cartons, boxes, printing)
- marine
- oecd biotech definition(food) *
- pulp and paper

sgc_3: energy*

- CCMT

sgc_4: transport

- aeronautics
- automobiles (cars and trucks)
- biofuels for transport *
- ccmts in transportation
- characteristics of vehicles
- infrastructure
- intelligent transport/navigation
- logistics/handling
- new power train *
- ships

- trailer and other wheelers
- trains

sgc_5: climate *

- air
- air quality management
- bio-materials
- forests, flora, fauna
- noise
- other
- soil
- waste management and recycling
- water and wastewater